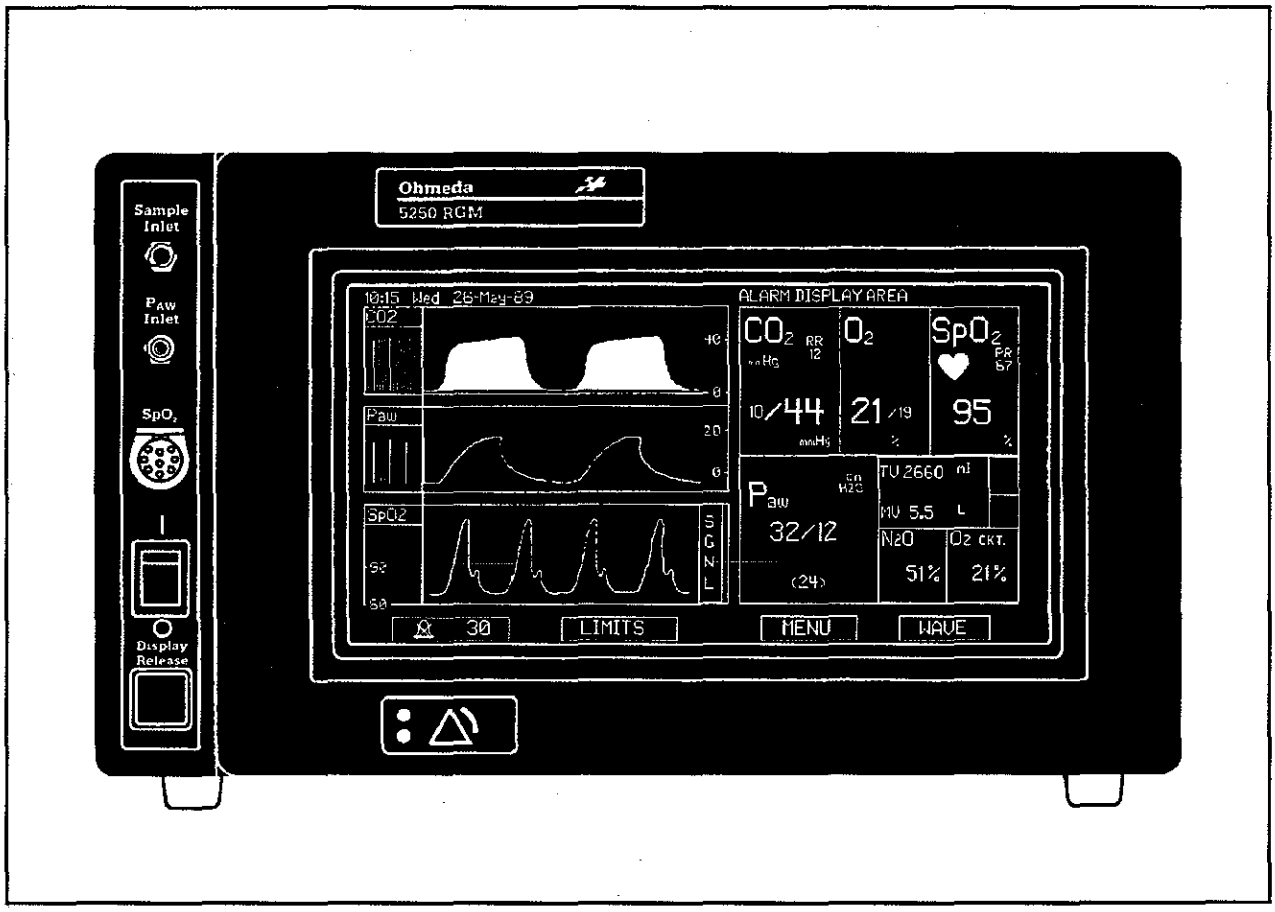
Ohmeda

5250 Respiratory Gas Monitor

Service Manual



A BOC Health Care Company

Critical Care Worldwide

6050 0001 056
05 91 C 10 11 13
Printed in the USA

The software features and functions described in this manual apply to Rev 3.0 or greater of the display processor and signal processor. If you do not have Rev 3.0 or later, contact Customer Service at the toll free number on the back page of this manual. The Service Screen shows your current revision level.

This service manual describes the following 5250 Respiratory Gas Monitors:

Basic RGM.....**6051-0000-009**
(Includes CO_2, O_2, N_2O, Airway Pressure, Tidal and Minute Volume, Resp. Rate, and Circuit O_2)

* **Basic RGM with SpO_2** **6051-0000-010**

Basic RGM with Agent.....**6051-0000-011**

* **Basic RGM with Agent and SpO_2**.....**6051-0000-012**

* For RGMs with the oximeter (MINX) board, a separate service manual is included, the *Ohmeda MINX Manual*, 0380-0900-090.

* For RGMs with the oximeter (MINX) board, a Probes manual is included:

Probes Manual	English,	1000-304 (0380-0900-085)
	Swedish,	1000-305
	French,	1000-306
	German,	1000-307
	Spanish,	1000-308
	Italian,	1000-309

Note: TUV, the German regulatory agency, stipulates certain electrical requirements set forth in IEC-601. Serial numbers of monitors that include the TUV changes begin with FARU, and/or the TUV label appears on the monitor's rear panel.

Differences in the repair procedures due to the TUV changes are noted by the placement of TUV in parentheses beside the change.

This document is not to be reproduced in any manner, nor are the contents herein to be disclosed to anyone, without the express authorization of the Product Service Department, Ohmeda, Ohmeda Drive, Madison, Wisconsin 53707.

© BOC Health Care Inc 1989, 1990, 1991 All Rights Reserved

Important

The information contained in this service manual pertains only to those models of products marketed by Ohmeda as of the effective date of this manual or the latest revision thereof. This service manual was prepared for exclusive use by Ohmeda service personnel in light of their training and experience as well as the availability to them of parts, proper tools and test equipment. Consequently, Ohmeda provides this service manual to its customers purely as a business convenience and for the customer's general information only without warranty of the results with respect to any application of such information. Furthermore, because of the wide variety of circumstances under which maintenance and repair activities may be performed and the unique nature of each individual's own experience, capacity, and qualifications, the fact that the customer has received such information from Ohmeda does not imply in anyway that Ohmeda deems said individual to be qualified to perform any such maintenance or repair service. Moreover, it should not be assumed that every acceptable test and safety procedure or method, precaution, tool, equipment or device is referred to within, or that abnormal or unusual circumstances, may not warrant or suggest different or additional procedures or requirements.

This manual is subject to periodic review, update, and revision. Customers are cautioned to obtain and consult the latest revision before undertaking any service of the equipment. Read completely through all steps in a procedure before starting the procedure; any exceptions may result in a failure to properly and safely complete the attempted procedure.

Comments and suggestions about this manual are welcomed from our customers. Please send them to Technical Publications, Ohmeda, 1315 W. Century Dr., Louisville, Colorado 80027.

CAUTION: Servicing of this product in accordance with this service manual should never be undertaken in the absence of proper tools, test equipment, and the most recent revision to this service manual, which is clearly and thoroughly understood.

CAUTION: Federal law in the USA and Canada restricts this device to sale by or upon the order of a licensed medical practitioner.

Technical Competence

The procedures described in this service manual should be performed only by trained and authorized personnel. Maintenance should be undertaken only by competent individuals who have knowledge of and experience with medical electronic devices. No repairs should ever be attempted by anyone not having such qualifications. Ohmeda recommends that only genuine replacement parts, manufactured or sold by Ohmeda be used for all repairs.

Table of Contents

Important i
Table of Contents iii
List of Figures x
Precautions xiv
Warnings xiv
Cautions xv

1/Introduction 1-1
1.1 How the Manual Is Structured 1-1
1.2 RGM General Features 1-2
A. Display Panel 1-2
B. Gas Sample Measurement 1-2
C. Internal O2 Measurement 1-2
D. Airway Pressure Measurement 1-3
E. SpO2 Measurement 1-3
F. Circuit O2 Measurement 1-3
G. Flow Volume Measurement 1-3
H. Alarm Features 1-3
I. 78xx Ventilator Interface 1-3
1.3 Major Components 1-4
A. The Chassis Assembly 1-4
B. The Display Panel Assembly 1-4
C. The Front Panel Assembly 1-4
D. The Rear Panel Assembly 1-4
1.4 Line Voltage Selection 1-5

2/Theory of Operation 2-1
2.1 Power Input Assembly 2- 1
A. Toroid 2- 1
B. Fuses 2-1
C. Connectors 2-2
2.2. Power Supply Board 2-3
A. General 2-3
B. Main Regulators 2-3
C. Power Monitor 2-5
D. Display Preregulators 2-6
E. Frequency Monitor 2-7
F. Infrared Photometer Source Switch 2-8
2.3 Motherboard 2-9
A. General Description 2-9
B. Rear Panel Connectors 2-10
Protection 2-10
Isolated RS-232 2-11

List of Figures

Figure 6-5. Communications or Signal Processor Fail and LED status 6-10

7/Repair Procedures

Figure 7-1. TUV Approval Label 7-1
Figure 7-2. Rear Panel TUV Indicators 7-1
Figure 7-3. Cover Removal 7-2
Figure 7-4. TUV SpO2 Connector Replacement 7-4
Figure 7-5. Display Panel Disassembly 7-6
Figure 7-6. Pre-TUV Rear Panel Disassembly 7-8
Figure 7-7. TUV Rear Panel Disassembly 7-9
Figure 7-8. Line Fuse Replacement 7-10
Figure 7-9 Photometer Replacement 7-11
Figure 7-10. Ground Wire Connection 7-12
Figure 7-11. Toroid Assembly Removal 7-13
Figure 7-12. Power Supply Fuse Replacement 7-14
Figure 7-13. Power Supply Assembly Removal 7-15
Figure 7-14. Signal Processor, SpO2, and Measurement Circuit Board Removal 7-16
Figure 7-15 SW1 Motherboard Jumper 7-19
Figure 7-16. Pneumatics Assembly Replacement 7-21

8/Service Parts List

Figure 8-1. Main Unit Assembly 8-3
Figure 8-2A part 1. Pre-TUV Access Panel Assembly, Front 8-5
Figure 8-2A part 2. Pre-TUV Access Panel Assembly, Back 8-6
Figure 8-2B part 1. TUV Access Panel Assembly, Front 8-7
Figure 8-2B part 2. TUV Access Panel Assembly, Back 8-8
Figure 8-3. Cord Box Assembly 8-9
Figure 8-4. Display Assembly 8-10
Figure 8-5. Pre-TUV Rear Panel Assembly 8-11
Figure 8-6. TUV Rear Panel Assembly 8-13
Figure 8-7. Power Supply Assembly 8-14
Figure 8-8. Pneumatics Assembly 8-16
Figure 8-9. Agent Photometer Assembly (ACX 100) 8-18
Figure 8-10. Non-agent Photometer Assembly (CX-104) 8-18
Figure 8-11. Toroid Assembly 8-20
Figure 8-12. Water Trap Sensor with Membrane Filter 8-21
Figure 8-13. Water Trap Sensor without Membrane Filter 8-22

9/Assemblies and Schematics

Figure 9-1. 5250 RGM Block Diagram
Figure 9-2 part 1 of 2 Toroid Assembly–Mechanical Rev J
Figure 9-2 part 2 of 2 Toroid Assembly–Electrical Rev J
Figure 9-3A part 1 of 3 Power Supply Board Rev J
Figure 9-3A part 2 of 3 Power Supply Board Rev J
Figure 9-3A part 3 of 3 Power Supply Board Rev J

Figure 9-3B part 1 of 2 Power Supply Board Rev F
Figure 9-3B part 2 of 2 Power Supply Board Rev F
Figure 9-4A part 1 of 2 TUV Motherboard
Figure 9-4A part 2 of 2 TUV Motherboard
Figure 9-4B part 1 of 2 Pre-TUV Motherboard
Figure 9-4B part 2 of 2 Pre-TUV Motherboard
Figure 9-5A part 1 of 3 Signal Processor Rev K
Figure 9-5A part 2 of 3 Signal Processor Rev K
Figure 9-5A part 3 of 3 Signal Processor Rev K
Figure 9-5B part 1 of 3 Signal Processor Rev H
Figure 9-5B part 2 of 3 Signal Processor Rev H
Figure 9-5B part 3 of 3 Signal Processor Rev H
Figure 9-5C part 1 of 3 Signal Processor Rev B
Figure 9-5C part 2 of 3 Signal Processor Rev B
Figure 9-5C part 3 of 3 Signal Processor Rev B
Figure 9-6 part 1 of 2 Pneumatics Interface Board
Figure 9-6 part 2 of 2 Pneumatics Interface Board
Figure 9-7A Display Processor Board Rev F
Figure 9-7B Display Processor Board Rev E
Figure 9-8 Display Processor–V25 CPU & Block Interconnections
Figure 9-9 Display Processor–Graphics Controller
Figure 9-10 Display Processor–Programmable Logic
Figure 9-11 Display Processor–V25 Memory
Figure 9-12 Display Processor–Display Memory & Output
Figure 9-13 Display Processor–Power & RS-422
Figure 9-14 Display Processor–Audio & Watchdog
Figure 9-15 Display Processor–Carroll Touch
Figure 9-16 Display Assembly with Display Matrix
Figure 9-17 SpO2 oximeter (MINX) board
Figure 9-18 part 1 of 2 SpO2 oximeter (MINX) board
Figure 9-18 part 2 of 2 SpO2 oximeter (MINX) board
Figure 9-19 Pneumatic Routing, Agent
Figure 9-20 Pneumatic Routing, Non-Agent
Figure 9-21 PCA Agent Measuring Board
Figure 9-22 part 1 of 3 Agent Measurement Board
Figure 9-22 part 2 of 3 Agent Measurement Board
Figure 9-22 part 3 of 3 Agent Measurement Board
Figure 9-23 part 1 of 2 Agent Preamplifier Board
Figure 9-23 part 2 of 2 Agent Preamplifier Board
Figure 9-24 PCA CO2 Measurement Board
Figure 9-25 CO2 Measurement Board
Figure 9-26 PCA CO2 Preamplifier Board
Figure 9-27 CO2 Preamplifier Board

Precautions

Two types of precautionary notes are used in this manual:

- **Warnings** alert the user to potential product use or misuse that could harm the user or others.
- **Cautions** alert the user to potential product use or misuse that could harm the product, associated equipment, or the surrounding environment.

The warnings and cautions that appear in the text of this manual are listed in the following sections:

⚠Warnings

Patient Safety–Use only Ohmeda probes with the RGM; otherwise, patient injury or equipment damage may result.

Patient Safety–Prolonged monitoring or patient condition may require changing the SpO_2 probe site periodically. Change the probe site at least every four hours to reduce the risk of blistering, skin erosion, or ischemic skin necrosis (especially if the site is poorly perfused).

A damaged membrane separator may result in a contaminated agent photometer. The agent photometer assembly **once contaminated** cannot be serviced and must be replaced.

After completing simulation testing, be sure to return the sensor to its correct orientation in the breathing circuit. The arrows should point away from the patient.

Electrical Shock Hazard–Disconnect the power cord before removing the cover for the replacement of parts.

Electrical Shock Hazard–Do not touch any exposed wiring or conductive surfaces while the cover is removed. The voltages present when electrical power is connected to the RGM can cause serious injury or death. Never wear a grounding wrist strap when working on an energized monitor.

For continued protection against fire hazard, replacement fuses must be the same type and rating as the original fuses.

For the 5250 RGM without Agent, use only Ohmeda calibration gas or a calibration gas of 6% CO_2 , 50% O_2, and 44% N_2O (±0.05% gravimetric standard). For the 5250 RGM with Agent, use only Ohmeda calibration gas of 4% Halocarbon-22, 6% CO_2 , 40% N_2O, and 50% O_2.

In the presence of alcohols, ketones, or other organic hydrocarbon vapors, the 5250 RGM will not indicate accurate readings of anesthetic agent. This includes their presence not only in the sample line or patient circuit, but also alcohol present in a patient's bloodstream.

Keep the circuit O_2 sensor attached to the unit to assure accuracy of O_2 readings. If detached, the sensor must be reattached and stabilized for an equivalent length of time (up to a maximum of 14 hours) before recalibrating.

Perform the checkout procedure before placing the RGM in use. If the RGM fails any test it must not be placed in use until it has been repaired and checked for correct operation.

The display generates potentially dangerous voltages (high voltage pulses up to 195 Vac). Do not touch the driver-controller circuit board during operation.

⚠Warnings (continued)

The flow sensor must be correctly oriented in the breathing circuit as indicated by the markings on the sensor clip. The arrows must point in the direction of the flow in the breathing circuit. If the clip is not mounted correctly, the RGM will not operate properly.

Use caution when handling tubing and other components of the patient circuit. Wear gloves, mask, and gown while handling components that come in contact with the patient's exhalant gas or fluids.

Use of the wrong calibration gas kit will result in improper calibration and the RGM will display incorrect gas concentrations.

⚠Cautions

After replacing the circuit oxygen sensor assembly, perform the circuit O_2 checkout procedure in Chapter 3 to verify that the RGM is working properly. Allow at least five minutes to stabilize the sensor.

After replacing the internal O_2 sensor, perform the calibration procedure in Section 3.6D to verify the RGM is working properly. Allow at least five minutes to stabilize the sensor.

If the O_2 sensor cartridge is not packaged with a shorting foil or clip, it must be shorted or installed in the monitor for as long as 14 hours before the sensor will meet specifications.

Detailed information for more extensive repairs is included in the service manual solely for the convenience of users having proper knowledge, tools, and test equipment, and for service representatives trained by Ohmeda.

Do NOT autoclave or pressure sterilize the 5250 Respiratory Gas Monitor.

Do not attempt to clean the sample chamber of an RGM with Agent. Cleaning may cause permanent damage to the sensor and void the warranty.

Do not use a strong alkaline detergent to clean the sample chamber of an RGM without Agent because alkaline detergent may corrode the aluminum casing.

Make sure the monitor voltage selected agrees with the local voltage available.

Malfunctioning flow cartridges must be destroyed to prevent their inadvertent use.

Never tamper with the set screws in the flow cartridge. Such action will render the cartridge unusable.

Only competent individuals trained in the repair of this equipment should attempt to service it.

Pressure in excess of 10 psi above atmospheric could damage the PAW transducer or sample system barometric pressure transducer in the RGM.

Precautions

Servicing of this product in accordance with this service manual should never be undertaken in the absence of proper tools, test equipment, and the most recent revision to this service manual, which is clearly and thoroughly understood.

System calibrations may be erased if power is applied while the signal processor software module is not in place.

The software for the 5250 RGM consists of two cartridges that must be replaced in sets to ensure software compatibility. The replacement procedures are outlined in Chapter 5 of this manual. The old software cartridges must be returned to the Ohmeda Colorado facility for credit.

The circuit board is subject to damage by static electricity. Handle only at an approved static control workstation.

This RGM contains electronic components that are susceptible to damage by electrostatic discharge. When disassembling the RGM, work at a static control workstation. Wear a static control wrist strap to discharge accumulated static charges from you and any tool you are using. Handle the circuit boards by their nonconductive edges. Use an anti-static container for transport.

When replacing either the microprocessor or the EPROM on the SpO_2 oximeter (MINX) board, be sure to use a Burndy QILEXT-1 extractor or equivalent to avoid damaging the components.

Maximum voltage. No more than 5 volts should appear on any pin of the analog output connector.

Do not attempt to repair or replace the photometer pressure transducer (B1). Each pressure transducer is specifically calibrated with selected resistors for use on a given board.

If you are installing a Rev E or earlier display processor into a new display rear housing (older housings have 4 standoffs, new rear housings have 3 additional standoffs in the cord strain relief area), apply a drop of hot melt glue (6016-0000-029) to insulate the circuit (non-component) side of the jumper wire in FB2 nearest the cable cutout. Let the glue harden before installing. Failure to insulate the standoff may short traces on the board.

This chapter describes how the manual is designed and presents a general introduction to the features and major components of the 5250 Respiratory Gas Monitor (RGM).

1.1 How the Manual Is Structured

The list below summarizes the contents of each chapter of the manual:

- Chapter 2 describes the theory of operation for the circuit boards and pneumatics system that supports the operation of the RGM.
- Chapter 3 includes the tests and checkout procedures used to assure that the RGM is operating correctly.
- Chapter 4 describes how to calibrate and adjust the RGM to the listed specifications.
- Chapter 5 describes the maintenance procedures to keep the RGM in operating order.
- Chapter 6 lists troubleshooting procedures to help locate and correct a malfunction.
- Chapter 7 details the repair procedures required to access or replace various components of the RGM.
- Chapter 8 includes the service parts list for the RGM.
- Chapter 9 is detailed assemblies and schematics.
- Appendices include the RGM accessories, specifications, alarms, and Material Safety Data Sheets.

If you are not familiar with the operation of the 5250 Respiratory Gas Monitor, read the *5250 Operation and Maintenance Manual,* part number 6050-0001-051.

Part numbers listed in this manual can be ordered from the Customer Service Department. Items not listed should be obtained locally from an electronic parts distributor.

CAUTION: Only competent individuals trained in the repair of this equipment should attempt to service it.

CAUTION: Detailed information for more extensive repairs is included in the service manual solely for the convenience of users having proper knowledge, tools, and test equipment, and for service representatives trained by Ohmeda.

Note: Monitors that include the oximeter (MINX) board are shipped with a separate service manual, *Ohmeda MINX Module Manual,* part number 0380-0900-090.

1.2 RGM General Features

A. Display Panel

The 5250 RGM uses a 4-by-8 inch amber electroluminescent flat display panel. The panel has infrared touch controls for using the RGM's software operations and is removable for easy access and viewing.

The RGM software program includes several service screens to aid in troubleshooting.

B. Gas Sample Measurement

The RGM uses the principle of infrared absorption to measure the amount of CO_2, N_2O, and anesthetic agent present in a gas sample. A small gas sample is continuously drawn into the pneumatic system (sample inlet) and routed through various components for conditioning (water separator, filters), analysis (photometer), flow control (pump, valve), and finally exhausted through a fitting (sample exhaust) on the back panel of the RGM.

The signal processor board monitors the flow within the pneumatic system (differential pressure sensor on the pneumatics interface board). A sudden drop in the flow or barometric pressure, indicating a blocked line or condensate in the sample line, causes the microprocessor to switch pneumatic valves, thereby shifting the sample flow through the water purge path of the pneumatics line to clear the condensate from the sample line.

The infrared analyzer (photometer and measurement board) determines the content of CO_2 and N_2O in the gas sample and generates a proportional analog voltage. The signal processor board digitizes the analog voltages and stores them for display.

In an RGM with a CO_2 N_2O/Agent gas analyzer, the measurement board sends the waveform information to the signal processor as a digital serial stream.

The stored values are continuously updated and displayed by the software program as numeric values, continuous waveforms, trend data, and respiratory rate data. The RGM determines a breath rate from the CO_2 activity.

C. Internal O_2 Measurement

An internal oxygen sensor measures the O_2 concentration of the sample gas. The response time of the sensor cartridge is very slow, so the signal processor triggers the solenoid sample valve alternately to sample inspired and expired gases. The presence of CO_2 in the gas triggers the collection of exhaled O_2 concentrations; while the absence of CO_2 triggers the collection of inhaled O_2.

For safety reasons, the solenoid is normally open to the O_2 sensor when it is not energized. This allows the RGM to continuously measure and display the average O_2 concentrations.

D. Airway Pressure Measurement

The pressure transducer on the pneumatics interface board measures the airway pressure when the patient circuit is connected to PAW inlet.

E. SpO_2 Measurement

The SpO_2 probe provides continuous, real time SpO_2, and pulse rate readings. Trend information is available on the display.

The RGM determines the patient's arterial oxygen saturation (SpO_2) and pulse rate by measuring the absorption of selected wavelengths of light. The light generated in the probe passes through the tissue and is converted to an electronic signal by the photodetector. (Some light is absorbed by the tissue.) The electronic signal passes to the oximeter and is amplified. The oximeter's circuitry processes the signal, converting the light intensity information into SpO_2 and pulse rate values. The patient data then appear.

F. Circuit O_2 Measurement

The circuit oxygen sensor monitors the O_2 concentration at an external sensor cartridge. The oxygen sensing cartridge produces a voltage that is proportional to the oxygen concentration (partial pressure) at its detecting surface. The signal processor board converts the sensor signal into a corresponding percent oxygen. The O_2 values then appear.

G. Flow Volume Measurement

The RGM uses a turbine vane transducer cartridge and a sensor clip, placed in the patient breathing circuit, to convert gas flow into electrical pulses. A clip-on optical coupler sensor fastens to the transducer cartridge and connects to the RGM with a flexible, extendible, coiled cord. The signal processor analyzes the signals from the transducer to determine tidal and minute volumes, whose values appear on the screen.

H. Alarm Features

The RGM generates various alarms and messages to indicate conditions of the gas sample, SpO_2 probe, oxygen probe, flow sensor, and of the RGM itself.

The RGM evaluates each condition, compares it to an operator selected limit or to a system default value and generates audible alarms, visual alarm indicators, and alphanumeric messages indicating the cause of the alarm: patient (gas sample) or RGM related.

I. 78xx Ventilator Interface

The RGM can be used with Ohmeda 7800 and 7810 ventilators, which are referred to as 78xx. The xx is a variable that represent either ventilator. An RS-232 cable connects the ventilator to the RGM and transmits values (TV, MV, PAW [min, max, inspiratory pause], and Circuit O_2) calculated by the ventilator to the RGM, which displays the values received from the 78xx ventilator. In order to use a ventilator with the RGM, the required ventilator software revision level for the 7800 ventilator is 1.10 or later, and for the 7810 Revision 3.0 or later is required.

1.3 Major Components

The RGM is made up of four major assemblies: the chassis assembly, the display panel assembly, the front panel assembly, and the rear panel assembly.

A. The Chassis Assembly:

- Power input assembly
- Power supply assembly
- Motherboard
- Pneumatics assembly
- Pneumatics interface board
- CX-104 or ACX photometer
- CX-104 or ACX measurement board
- Signal processor board
- SpO_2 oximeter (MINX) board
- Signal processor software module

B. The Display Panel Assembly:

- The display panel and extension cord
- Display processor board
- Display matrix assembly
- Touch panel
- Display processor software module

C. The Front Panel Assembly:

- Gas sample inlet
- P_{AW} inlet
- SpO_2 connector
- Power switch
- Display release
- Water separator assembly

D. The Rear Panel Assembly:

- Cooling fan
- Gas sample exhaust
- Software module access cover
- Equipotential ground connector
- Power input receptacle (line filter, fuses, voltage selector)

1.4 Line Voltage Selection

The 5250 RGM covers four (100, 120, 220, 240) line voltage applications.

- As received domestically, the RGM is set up to operate from a 120 volt AC power source (50/60 Hz). If the RGM is ordered with the correct country option, the line voltage and fuses will be set appropriately for the destination country.
- To use the RGM from an alternate power source, change the fuses, the voltage selector switch (drum), and the power cord to match the application. Refer to Chapter 5.

CAUTION: Make sure the monitor voltage selected agrees with the local voltage available.

Notes

2.1 Power Input Assembly

The power input assembly consists of:

- Power input module
- Power switch
- Surge suppressors (MOV1 and MOV2)
- Toroid
- Secondary fuses

The power switch (SW1) on the front panel of the RGM connects the power input module to the toroid (T1) and power surge suppressors MOV1 and MOV2 through connectors J2 and P1.

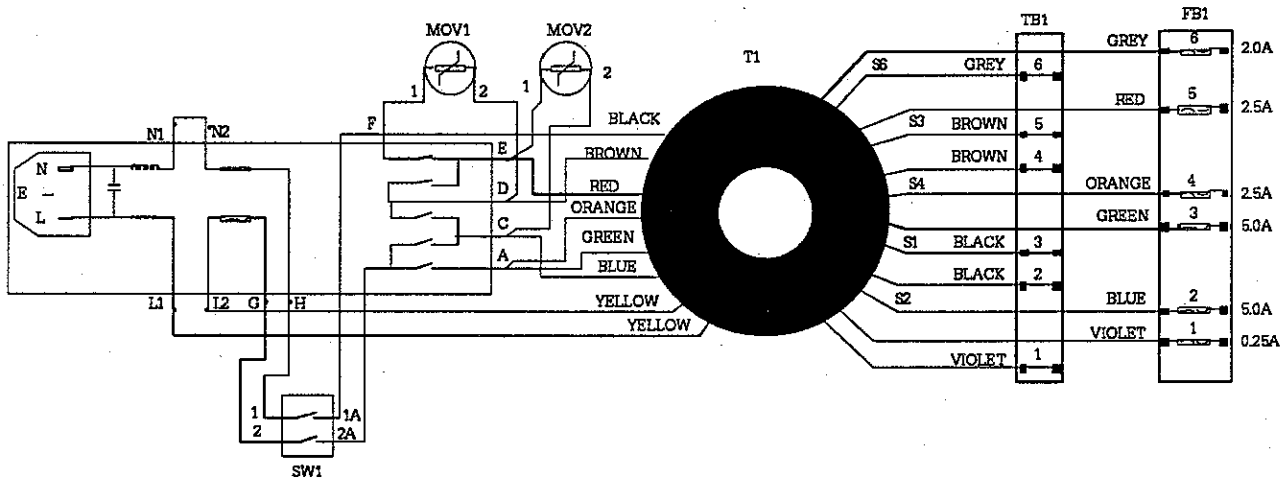


Figure 2-1. Power Input Assembly
(From the Power Supply schematic)

2/Theory of Operation: Power Input Assembly

A. Toroid

The toroid is a power efficient step-down transformer, used in this unit for space and size considerations.

B. Fuses

The primary fuses are located in the power input module. To replace the fuses refer to the maintenance section. The secondary fuses are 5-by-20-mm fast blow types. One fuse connects to each secondary winding of the toroid.

C. Connectors

Connectors TB and FB connect the secondary windings of the toroid to the power supply board. The table below lists the corresponding connectors between the input assembly and the power supply.

Input Assembly	Power Supply	Volts AC	Wire Color
TB5	E1	0 (GND)	Brn
TB4	E2	0 (GND)	Brn
TB6	E3	11.5 (Spare) *	Gry
FB6	E4	11.5 (Spare) *	Gry
FB5	E5	22.0	Red
FB4	E6	22.0	Orn
TB3	E7	0 (GND)	Blk
TB2	E8	0 (GND)	Blk
FB3	E9	9.5	Grn
FB2	E10	9.5	Blu
TB1	E11	11.5 (RS-232) *	Vio
FB1	E12	11.5 (RS-232) *	Vio

* These float with respect to system GND and can be measured only as a differential pair.

2.2. Power Supply Board

A. General

Refer to the schematics section.

The power supply board provides outputs of +5 Vdc, -5 Vdc, +15 Vdc, and -15 Vdc for all the boards in the RGM. In addition, it supplies +5V_ISO for the RS-232 connection, and a spare +5V supply for future enhancements.

The power supply has a circuit that monitors the incoming power for an adequate voltage level for proper operation, and it employs conventional linear regulation to provide power free of switching transients.

The inputs to the power supply are fused on a terminal strip connector. Another circuit passes a line frequency logic signal to the signal processor, which is used to synchronize the SpO_2 (MINX) oximeter board.

B. Main Regulators

The regulators VR1, VR3, VR4, and VR5 are for main system operation while the VR6 is an isolated regulator for external serial communications. All of these plus VR2 (SPARE) are single chip three-terminal adjustable regulators.

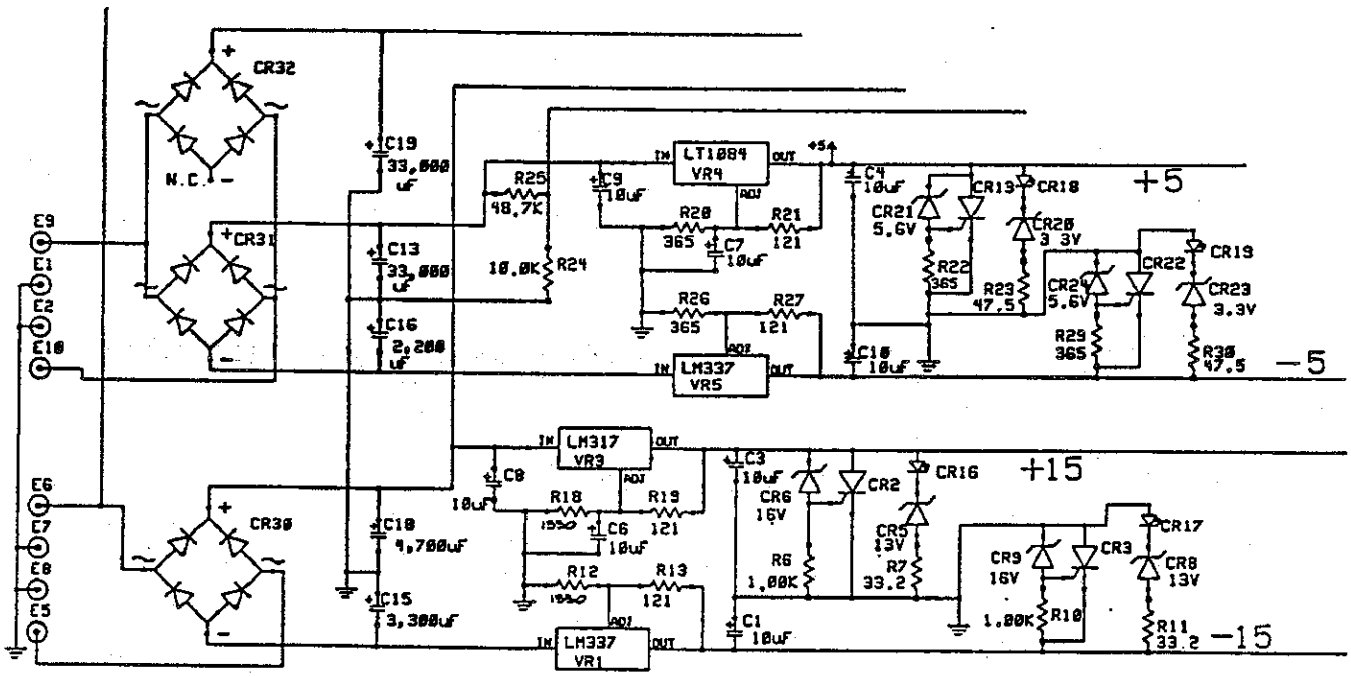


Figure 2-2. Power Supply Regulators ±5V, ±15V

(From the Power Supply schematic)

Major Components for Each Channel

Channel	Filter	Regulator	SCR	LED
+5	C13	VR4	CR13	CR18
-5	C16	VR5	CR22	CR19
+15	C18	VR3	CR2	CR16
-15	C15	VR1	CR3	CR17
V_ISO	C20	VR6	CR27	CR14
SPARE	C17	VR2	CR12	CR15

Each regulator has an over voltage protection circuit consisting of a zener diode and resistor to set a threshold and an SCR, which will short out the regulator if the threshold is exceeded.

The main regulators have indicator LEDs with a zener in series, so even a minor reduction in output (10%) will extinguish the LED.

A decoupled +5-volt output is provided (by L1 and C11) for the analog power for the SpO_2 oximeter (MINX) board

The +5-volt regulator (VR4, an LT1084) is a low overhead voltage part, with the transformer winding chosen for minimum overhead at line voltage of 103 Vac. Since the -5-volt regulator is powered from of the same winding, a greater ratio of capacitance (C16) to current reduces ripple, and therefore provides the extra overhead for the standard regulator.

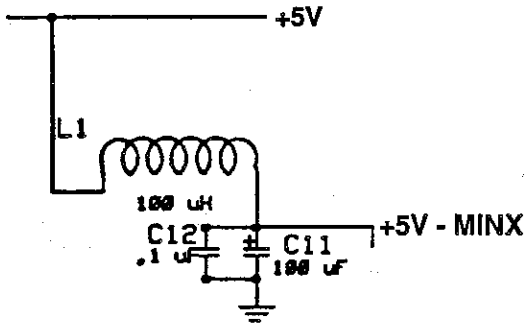


Figure 2-3. Decoupled +5V for Oximeter
(From the Power Supply schematic)

C. Power Monitor

The Power Monitor circuit has two functions. One is to monitor the main +5 Vdc regulator's unregulated input to let the signal processor know when power has been shut off, giving it enough time to shut down in an orderly way. The circuit's output is routed to the watchdog chip, U18, on the signal processor board, which compares this to a 1.3 volt internal reference. The watchdog chip will trip when the +5 V unregulated drops below a threshold, which varies from 6.9 to 8.4 volts depending on revision levels and signal processor boards. This allows at least 12 mS of continuing operation before the regulator drops out. The other function of the circuit is to ensure that the voltage being monitored will not exceed the +5.5 Vdc maximum input voltage to the watchdog chip.

Power Monitor Circuit (four revision levels)

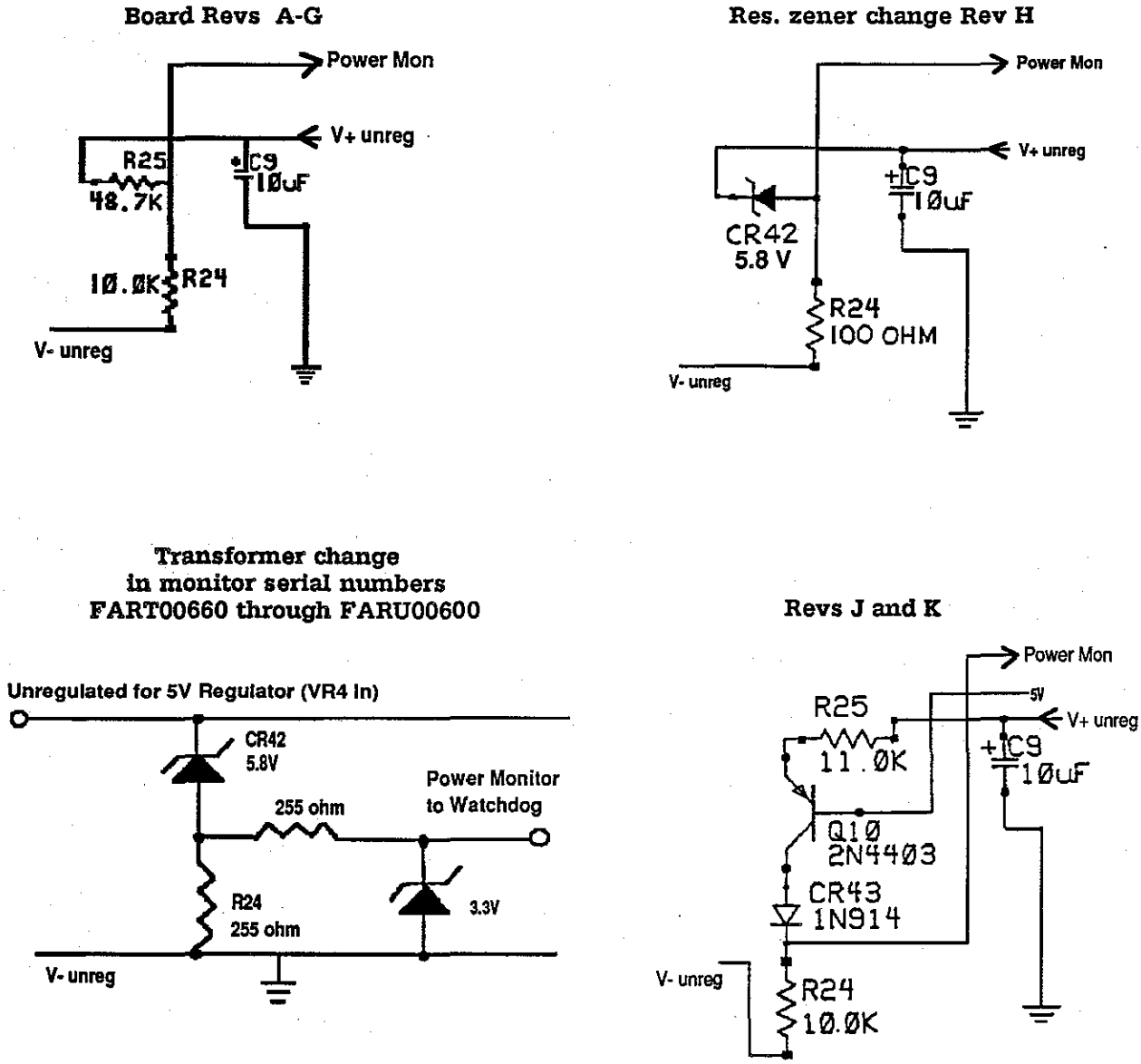


Figure 2-4. Power Monitor Circuit (four revision levels)

D. Display Preregulators

Because the display operates at the end of a long cord, two preregulators on the power supply minimize the voltage drop for the final regulators in the display.

Each preregulator consists of a PNP pass transistor (Q1 and Q2) controlled by an NPN transistor (Q4 and Q5) collector driving the base of the PNP. A REF01 (U1) provides a ten-volt reference to both circuits. Feedback is returned to the emitters of the NPN transistors, with diodes (CR4 and CR7) for temperature compensation.

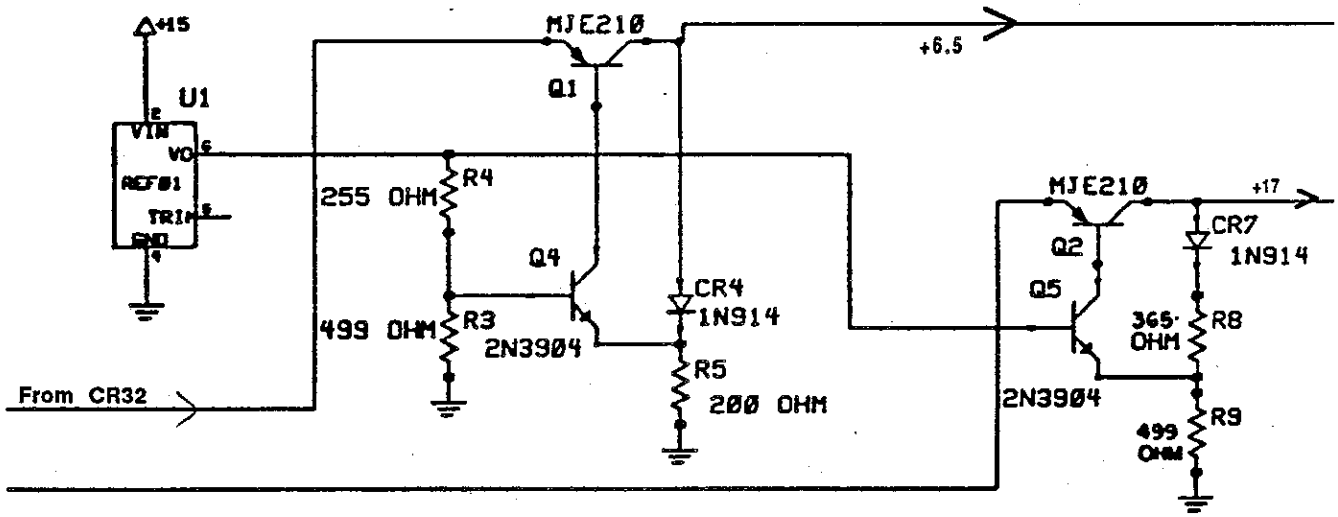


Figure 2-5. Preregulators for Display
(From the Power Supply schematic)

E. Frequency Monitor

One of the transformer windings, E6, used for the 15-volt outputs runs to a simple one-transistor amplifier to produce a square wave that tracks the polarity of the input sine wave. This is routed to the signal processor board, which measures the cycle time, and the signal processor board then informs the SpO_2 oximeter (MINX) board of the current line frequency.

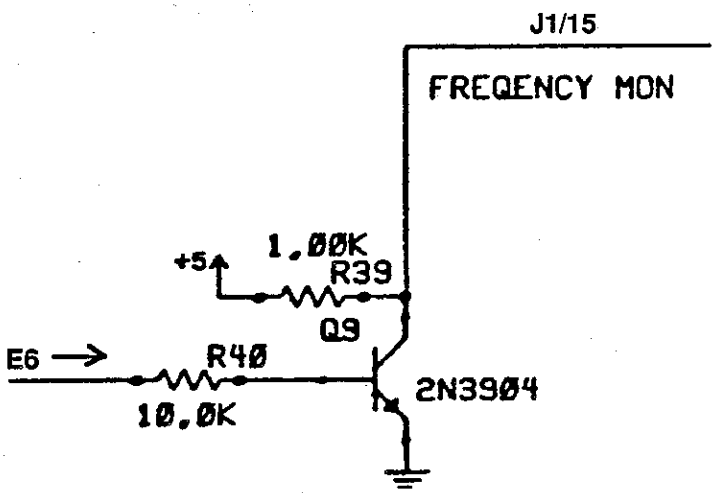


Figure 2-6. Frequency Monitor
(From the Power Supply schematic)

F. Infrared Photometer Source Switch

Q8 switching ON provides a current path to ground. This turns on the I.R. source Bench Lamp in the photometer in response to the LAMP CTL signal from the photometer measurement board. Q7 and the surrounding resistor network provide a 0 or 15 volt input to Q8 in response to a LAMP CTL +4 to +15 volts ON command or 0 to -15 volts OFF command. This range is necessary to accommodate either the CX104 analyzer, which has an op-amp output swinging between +15 to -15 volts, or the ACX analyzer, which has CMOS logic output levels.

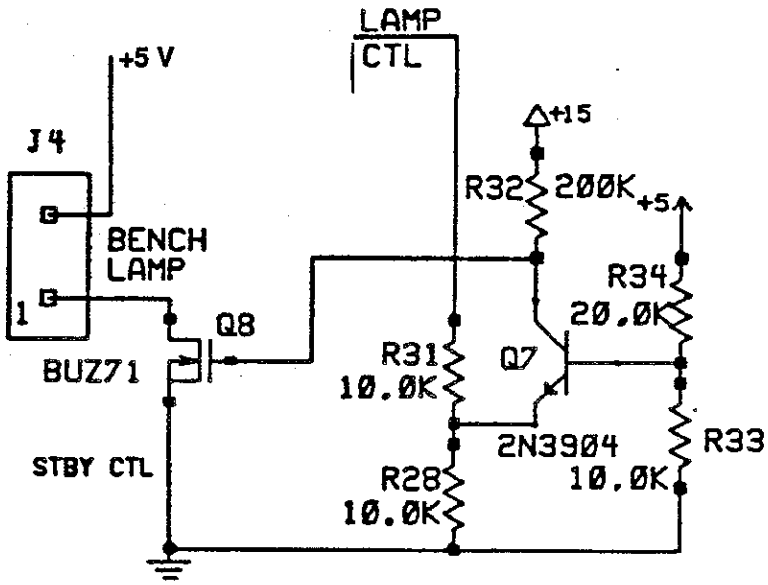


Figure 2-7. I.R. Photometer Source Switch
(From the Power Supply schematic)

2.3 Motherboard

A. General Description

Refer to Figure 9-4 parts 1 and 2.

The motherboard interconnects the signal processor, the SpO_2 oximeter (MINX) board, the IR photometer analyzer boards, the display, and the rear panel connectors. The system power enters the motherboard at J10 and is distributed to the boards and display. Serial drivers to the display and to the RS-232 port are also located on the motherboard.

This board is not bussed, so each daughter board has a specific socket:

Signal processor board	- J7
SpO_2 oximeter (MINX) board	- J8
Measurement board	- J9

The motherboard can accept either the CX104 measurement board or ACX measurement board. Resistors R18-R21 provide coarse settings for span and zero for the CX104 board.

B. Rear Panel Connectors

The TVX and O_2 inputs (J4 and J3) of the pre-TUV RGM are compatible with sensors for the Ohmeda 5410/20 and the 5120 monitors respectively.

For the TUV RGM, the rear panel connector is compatible only with the new TVX cable, which provides cable shielding.

The RS-232 channel operates through a 9-pin DB type connector; J2, is wired as follows:

2	Transmit
3	Receive
5, 7	Common
9	Alarm silence (transition high to low) (Available in software rev. 4.0 or greater)

The Analog output (J5) is wired with channels 1-7 on consecutive pins running clockwise from the gap at the top of the connector and from the common on the center pin. (See the Analog Output section in the Appendix.)

Protection

With the exception of the isolated RS-232 port, all of the rear panel connectors are protected against electrostatic discharge by five-volt transorbs (CR1-CR13). The TVX inputs have 4.7K ohms in series (R6, R9), while the analog outputs have 100 ohms in series with each output and with the common (analog ground).

The TVX interface also includes a multi-hole ferrite block (L1) in series with each lead to limit electromagnetic emissions.

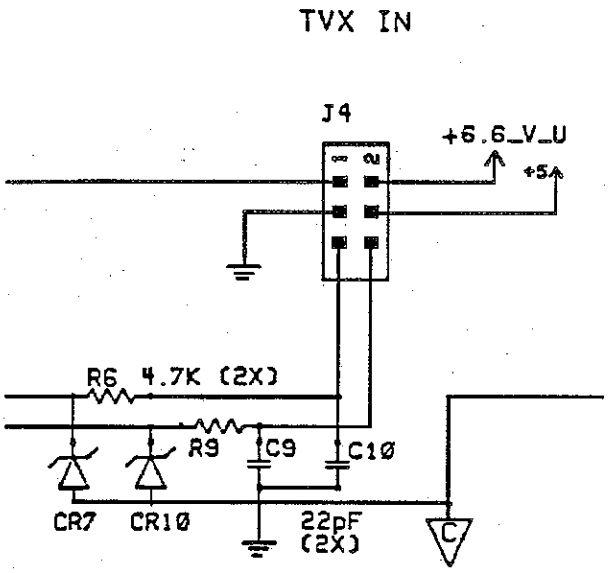


Figure 2-8A. TUV TVX Input
(From the TUV Motherboard schematic)

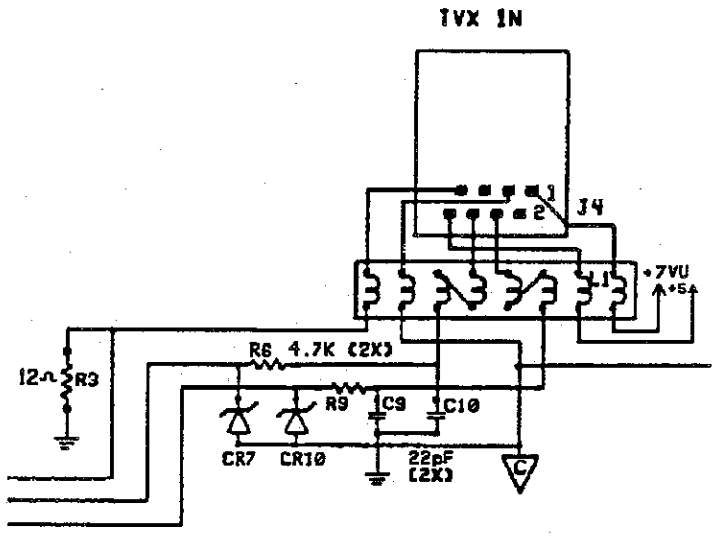


Figure 2-8B. Pre-TUV TVX Input
(From the Pre-TUV Motherboard schematic)

Isolated RS-232

The serial communications path is optically isolated by U3 for transmission and by U2 for reception. This allows the device attached to the RS-232 port to operate from a different ground reference.

U1, operating from an isolated 5-volt output of the power supply, converts between 5-volt logic levels and RS-232 levels. This IC uses capacitors C1 and C4-C6 to raise the 5 volts to ±10 volts.

An isolated channel also provides the alarm silence function.

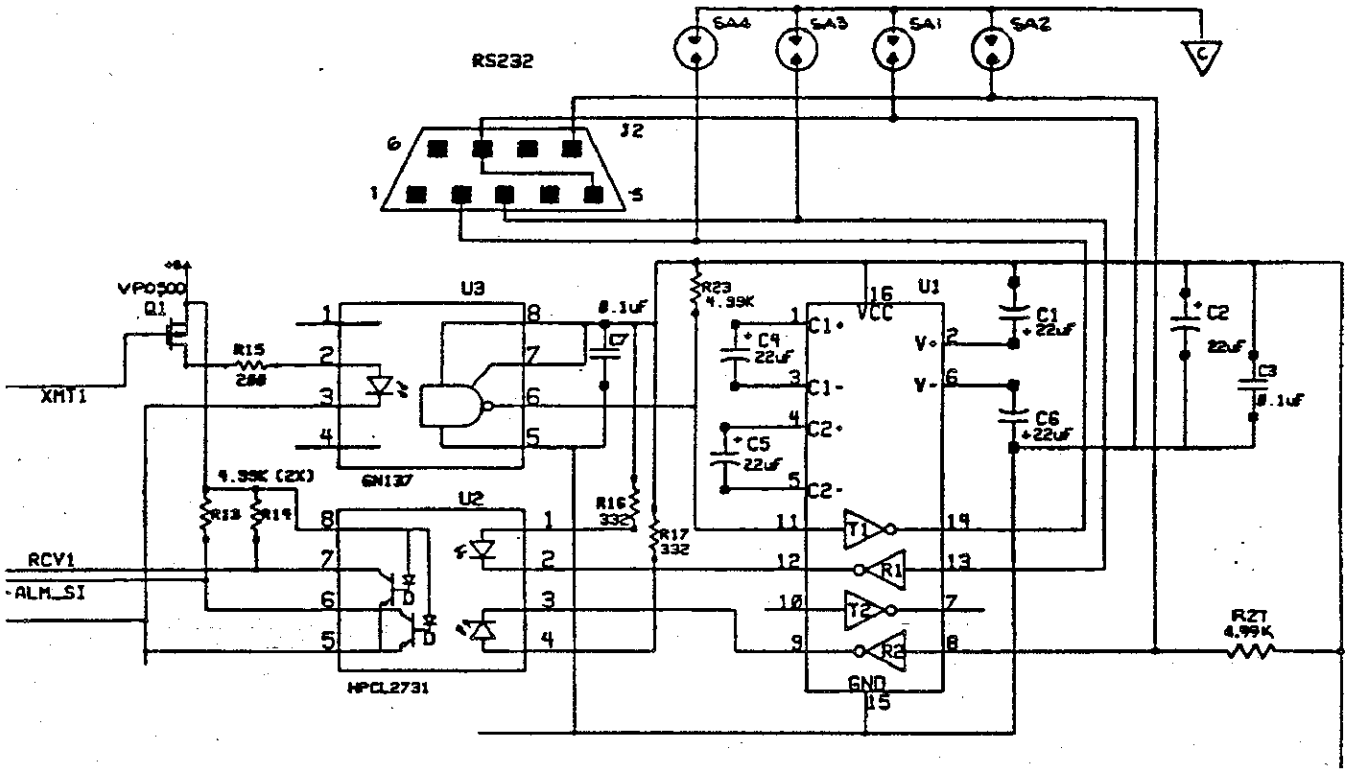


Figure 2-9. Isolated RS-232 Output
(From the Motherboard schematic)

C. Display Serial Driver

A driver (U4) converts the TTL/CMOS level serial string from the signal processor board into differential RS-422/485 levels for communications with the display through J11.

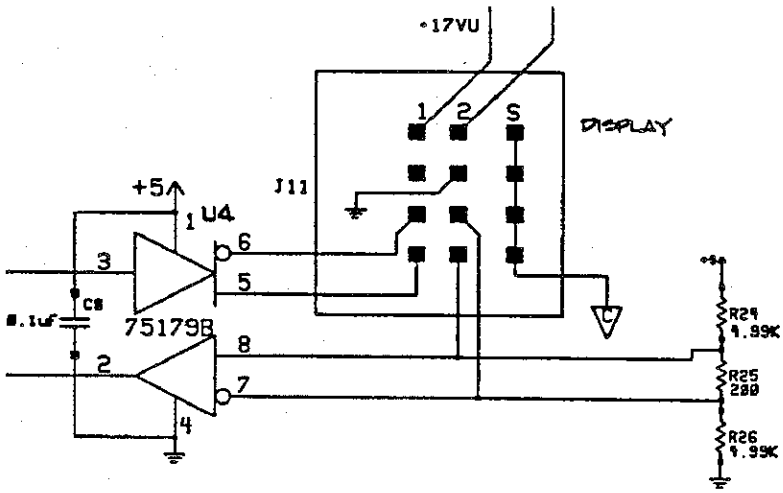


Figure 2-10. Display Driver
(From the Motherboard schematic)

D. Configuration Jumper SW1

A jumper pad (SW1) provides sense inputs for configuration information to the signal processor. Location of the jumper depends on whether the RGM is an agent (Figure 2-11) or non-agent (Figure 2-12) monitor.

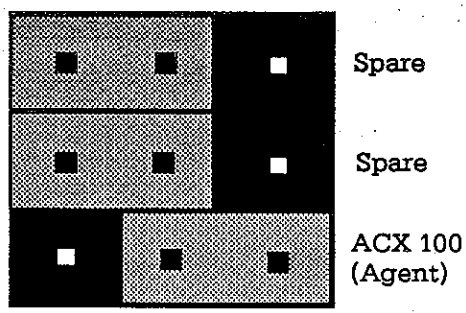


Figure 2-11. SW1 Motherboard (Agent)

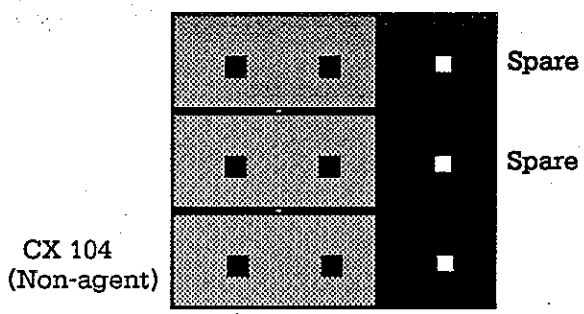


Figure 2-12. SW1 Motherboard (Non-agent)

Note: If the motherboard in your RGM is revision A or B and you have upgraded it to an agent monitor, SW1 is located on the motherboard between the 96-pin signal processor connector and the rear of the unit as shown in Figure 2-13. If your motherboard is Rev C or later, SW1 is located as shown in Figure 2-13.

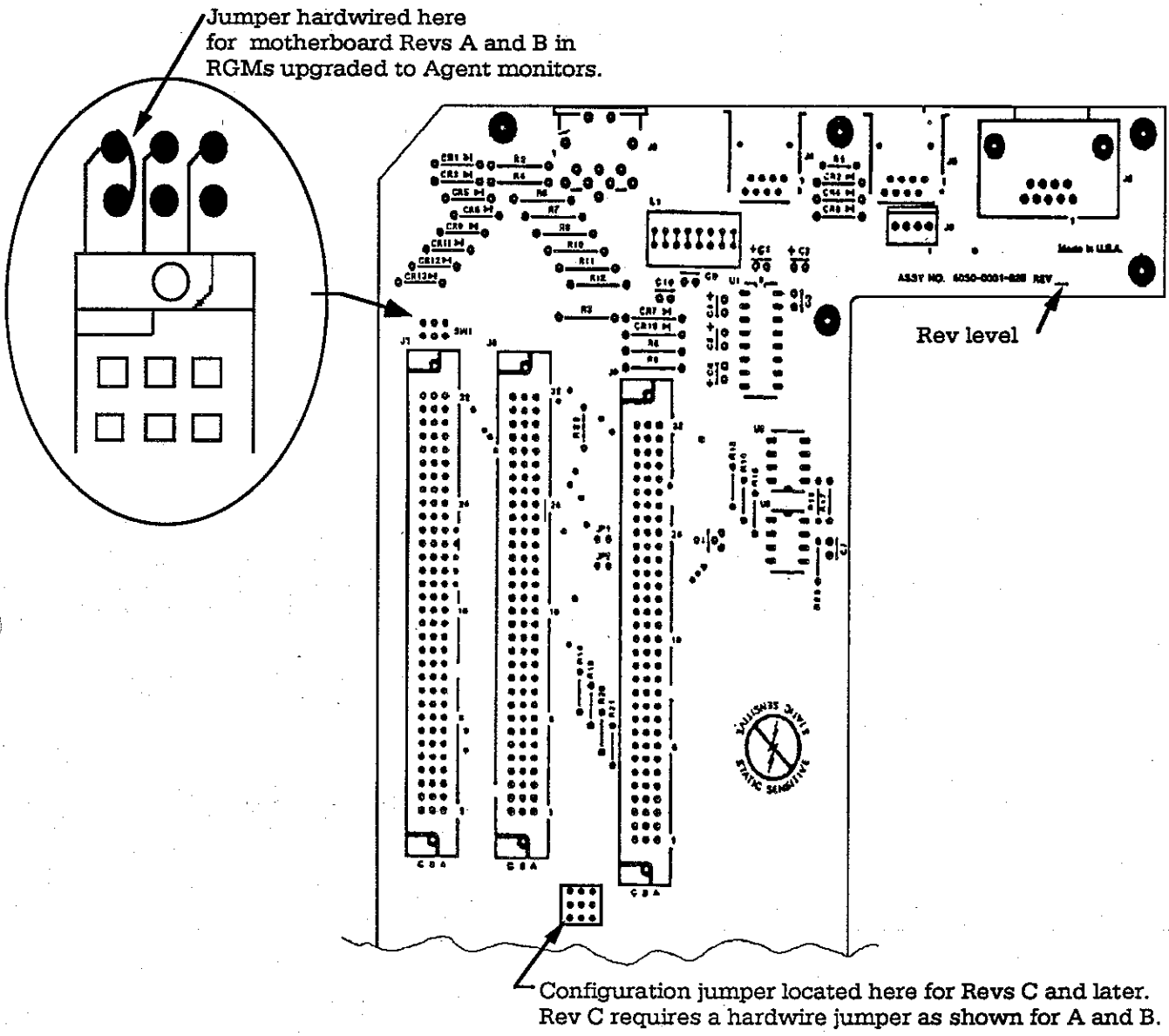

Jumper hardwired here
for motherboard Revs A and B in
RGMs upgraded to Agent monitors.
Rev level
Configuration jumper located here for Revs C and later.
Rev C requires a hardwire jumper as shown for A and B.

Figure 2-13. Motherboard Configuration Jumper for Revisions A, B, and C

2.4 Pneumatics Description

The pneumatics system has four basic functions:

- Drawing a gas sample from the patient breathing circuit via a gas sample tube
- Conditioning the gas by removing any water or other liquids as well as particulate matter
- Routing the clean, dry gas through the appropriate sensors for analysis
- Exhausting the gas to a scavenge system or back into the breathing circuit

A. Routing the Gas Sample

The RGM routes the sample gas through the pneumatics system in four methods:

- Normal flow with O_2 cell sampling
- Normal flow with O_2 cell bypassed
- Purge flow
- Manual/auto zero flow

B. Conditioning the Gas

Before being analyzed, the gas sample is conditioned by the water separator. The water separator extracts water and any other fluids from the gas sample. Two different separator styles appear on the RGM: a passive separator, or, a membrane separator with a replaceable filter cartridge.

If the water trap bottle is full, a sensor in the water trap shuts down the pump, and the RGM displays the WATER TRAP FULL message. The RGM resumes normal operation after the water trap bottle is emptied.

C. Normal Flow with O_2

Refer to Figure 2-14. The O_2 solenoid is deenergized (normally open position). The sample gas flows through the oxygen sensor. The oxygen sensor is used to sense both inhaled and exhaled gas. The flow rate is measured before the gas is exhausted through the pump and out of the machine.

The sample flow rate is in the range of 120 to 230 ml/min. The system is designed so that, during normal operation, 90% of the gas sample passes through the gas analyzer and oxygen sensor while 10% flows through the water separator bottle and then through the purge branch of the pneumatics.

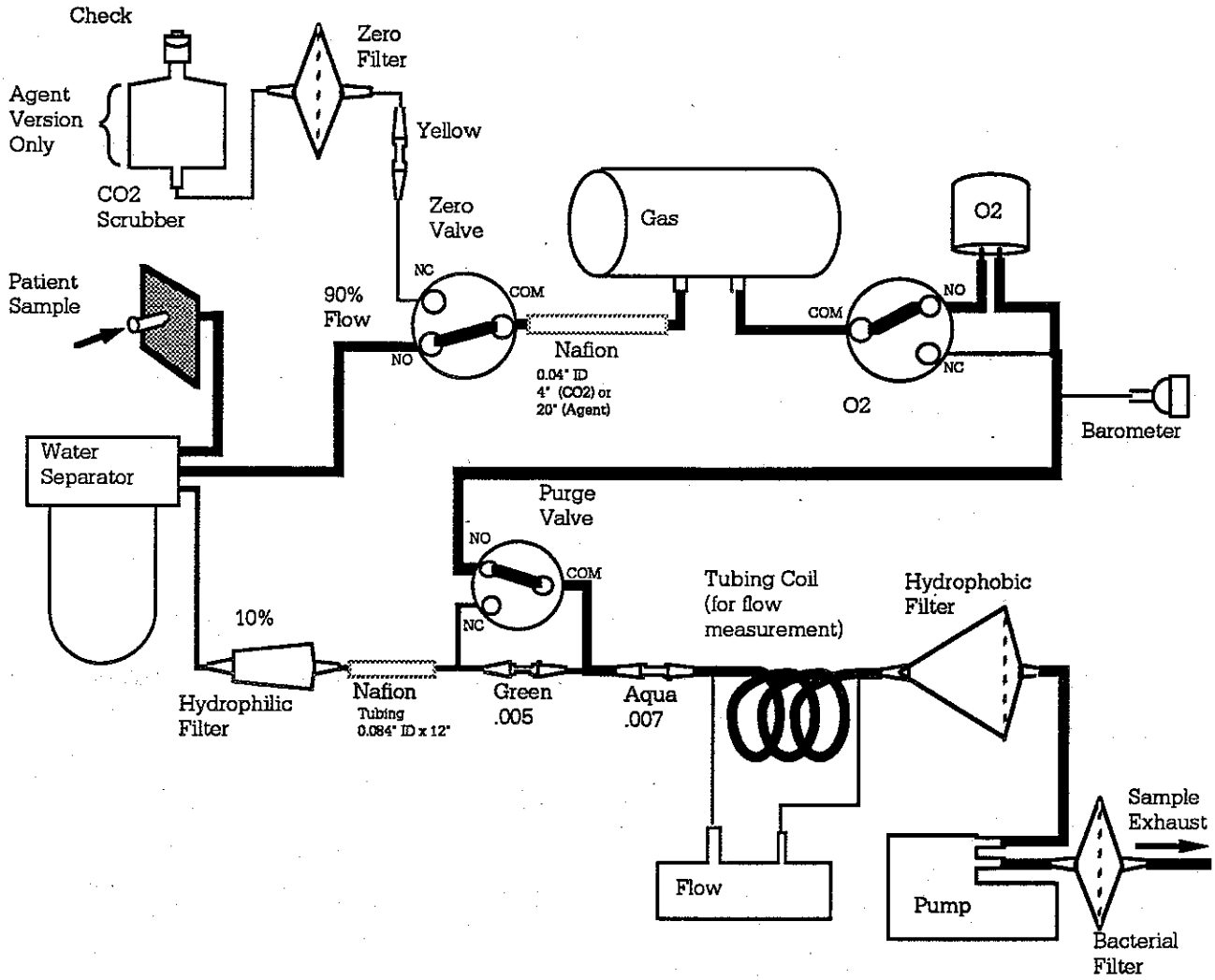


Figure 2-14. Normal Flow with O_2

D. Normal Flow without O_2

Refer to Figure 2-15. The level of CO_2 in the sample gas triggers the operation of the O_2 valve.

When the RGM is sampling inhaled gas:

The signal processor energizes the O_2 valve to bypass the oxygen sensor when the gas analyzer detects CO_2 in the system. The presence of CO_2 identifies exhaled gas. The previously inhaled sample gas is then trapped in the oxygen detector while the detector slowly responds to the trapped sample. The valve returns to normal flow when the analyzer detects the lack of CO_2 in the system once again.

When the RGM is sampling exhaled gas:

The process is reversed. The O_2 sensor is bypassed when the lack of CO_2 is detected, trapping the exhaled gas in the oxygen sensor.

This process allows the comparatively slow oxygen sensor to alternately sample inhaled sample gas for several breaths then exhaled sample gas for several breaths.

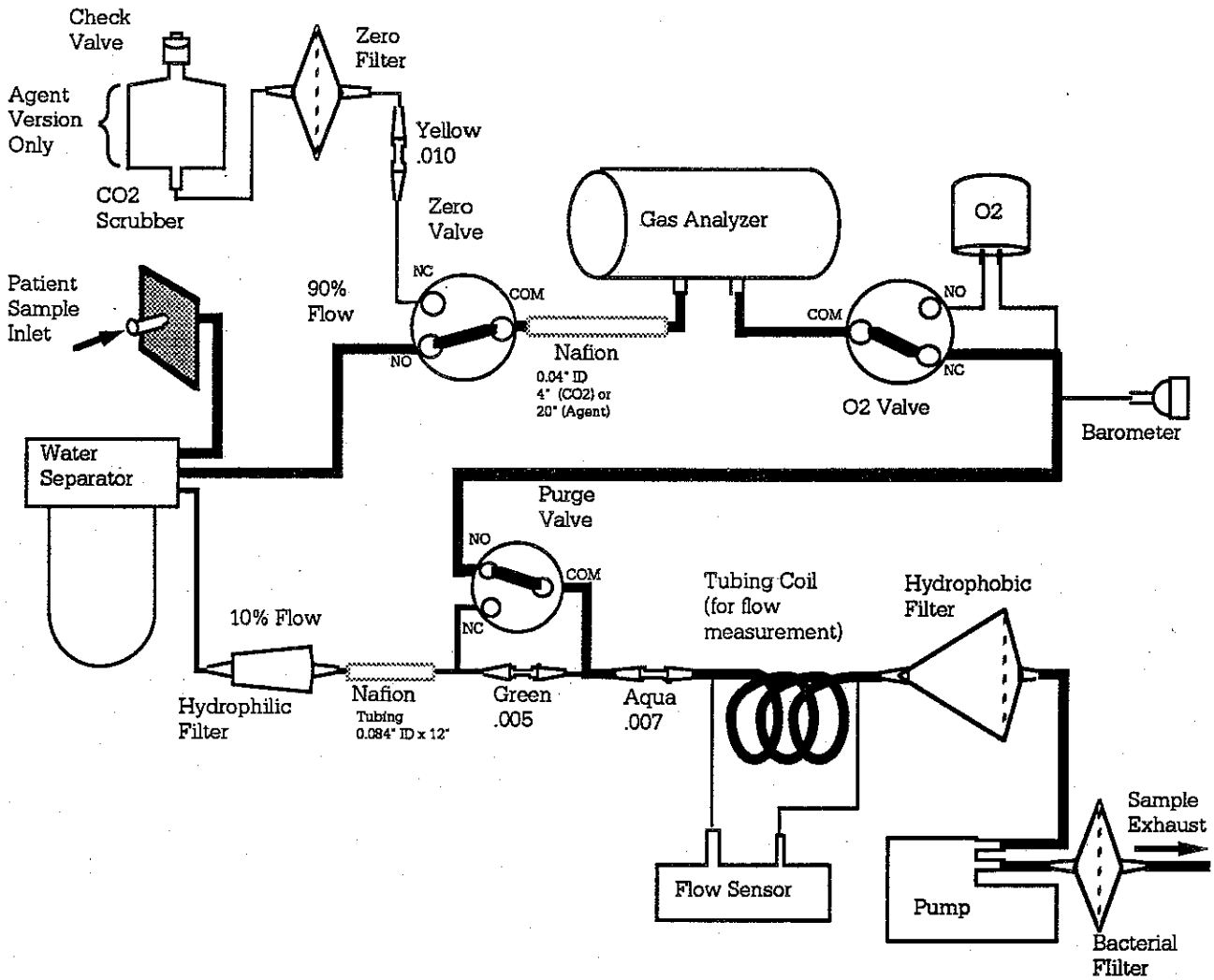


Figure 2-15. Normal Flow without O_2

E. Purge Flow

Refer to Figure 2-16. If the flow sensor detects a drop of 40 ml/min from the baseline flow or more than 90 torr below atmospheric pressure, the RGM enters a purge flow mode. The zero valve and purge valve will energize (NC position). This opens up the gas analyzer to the atmosphere and directs 100% of the sample gas through the water bottle.

The system tests the flow rate every five seconds. If the flow rate doesn't return to normal within 25 seconds, the SAMPLE LINE/FILTER BLOCKED or NO FLOW message appears. No flow is defined as less than 120 mL/min in the manual/auto zero state.

If the system bounces back and forth between purge flow and normal, the SAMPLE FILTER BLOCKED message appears. This means the membrane filter cartridge in the water separator is probably the cause of the line blockage and should be replaced.

WARNING: A damaged membrane separator may result in a contaminated agent photometer. The agent photometer assembly once contaminated cannot be serviced and must be replaced.

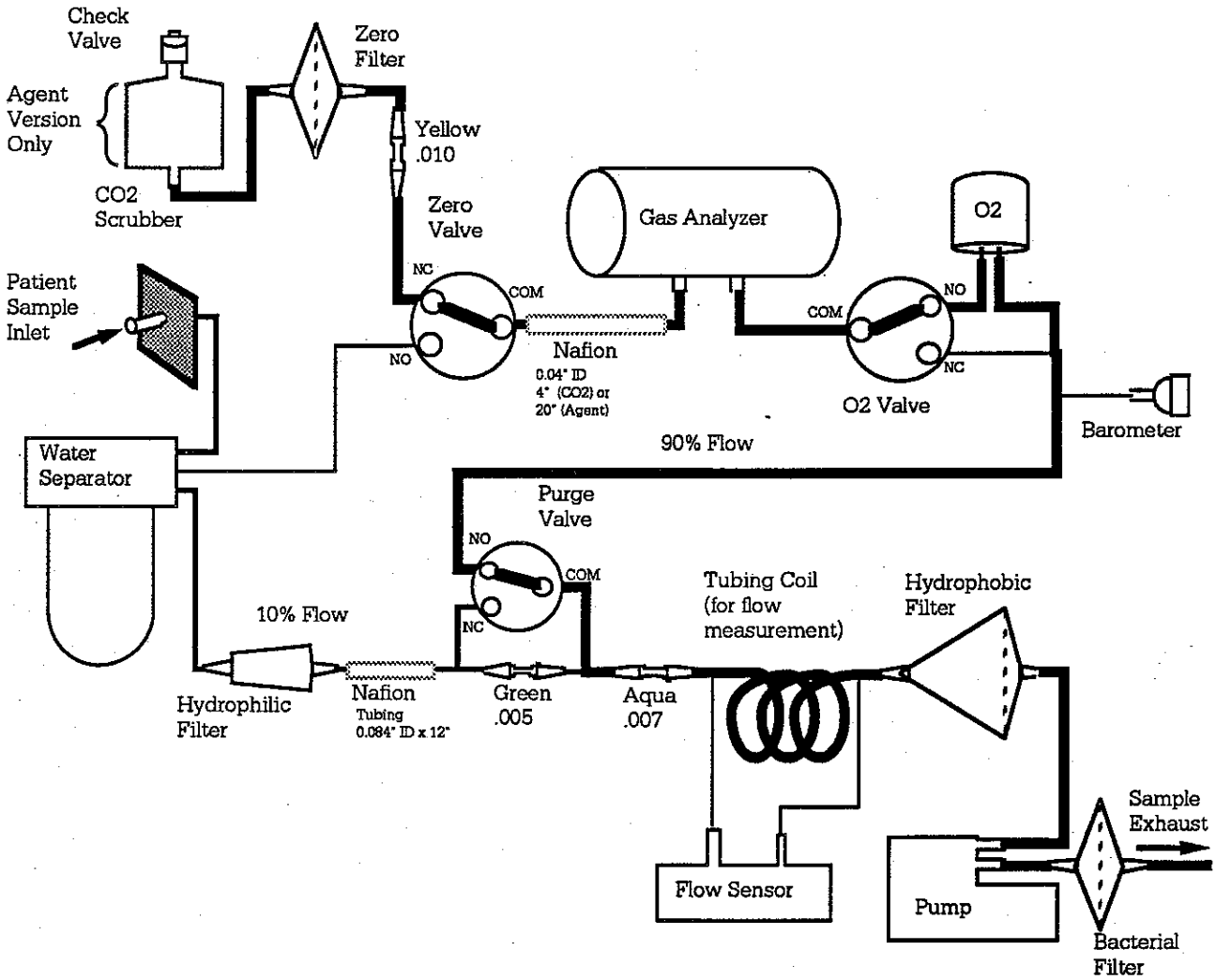


Figure 2-16. Purge Flow to Clear Blocked Line

F. Manual/Auto Zero Flow

Refer to Figure 2-17. The manual/auto zero flow mode is used to zero calibrate the gas analyzer. You can enter this mode manually through the Service Screens. The system automatically enters this mode periodically to compensate for the inherent drift of the analyzer. In this mode the zero valve is energized, and purge and O_2 valves are deenergized.

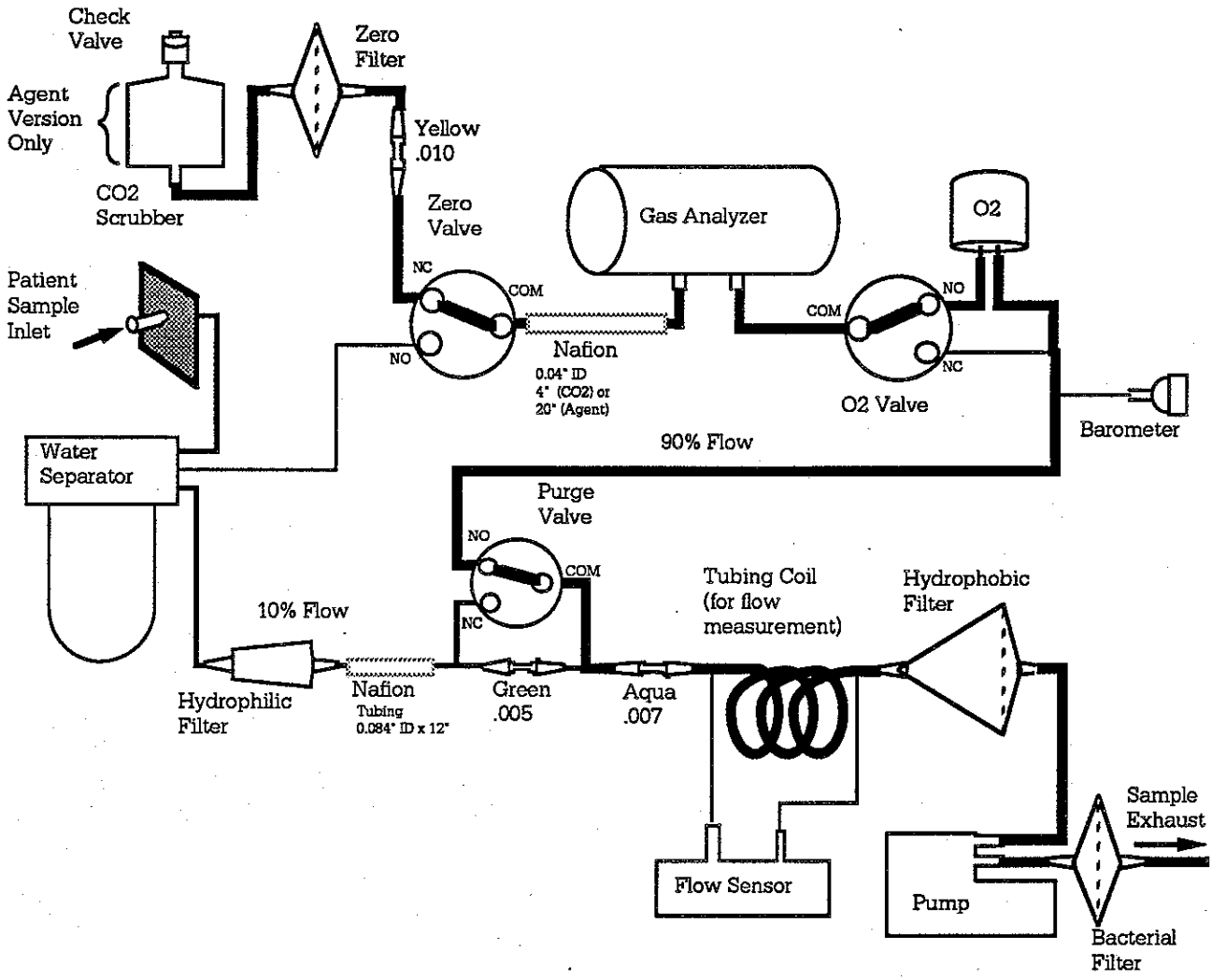


Figure 2-17. Manual/Auto Zero Flow

G. Analyzing the Dry Gas

The dry gas passes through the zero solenoid valve to a series of filters, valves, and detectors:

Infrared analyzer	Measures the percentage of N_2O and CO_2 (plus Agent if ACX is installed) in the gas sample. An infrared photometer and measurement board measure the amount of energy absorbed by the sample gas. The result is transmitted to the signal processor board and then to the display.
Oxygen sensor	Measures the percentage of O_2 in the gas sample. This sensor is measured by the pneumatics interface board.
Tubing coil	A length of coiled tubing. Flow is determined by the flow sensor, which measures the gas pressure drop across the coil.
Flow sensor	Measures the flow rate. Located on the pneumatics interface board.
Barometer	Measures the barometric pressure in the sample system. The pressure transducer is located on the measurement board.
CO_2 scrubber with check valve	For RGM with Agent only. Removes CO_2 from atmosphere before zero calibration of the analyzer. The check valve opens only when an auto zero is in progress. This valve can be built internally or externally to the scrubber itself.
Nafion[1] tubing	Evaporates condensed moisture and humidity of sample gas.
Zero filter	Removes unwanted particles from the zero gas sample.
Zero valve	Normally open (not energized) to direct sample gas to the analyzer. When energized, the valve switches position to allow atmospheric gas to enter the pneumatic system.
O_2 valve	Normally open (not energized). Bypasses the internal oxygen sensor when energized.
Purge valve	Normally open. Energizes during purge flow.
Yellow restrictor	Simulates the resistance of the patient tubing for the zero inlet.
Green restrictor	Produces the 90% and 10% gas flow proportioning at normal gas flow.
Aqua restrictor	Sets the overall flow rate for the system.
Hydrophilic filter	Removes particulate matter, but allows water to pass.
Hydrophobic filter	Protects the pump. Allows no water to pass.
Pump	Creates suction for the pneumatics system.
Bacterial filter	Filters exhaust gas.

[1] Trademark of E.I. DuPont de Nemours and Co., Inc.

H. Exhausting the Gas

After passing through the pump, the gas exhausts through the bacterial filter to the sample exhaust outlet on the rear panel of the RGM.

2.5 Pneumatics Interface Board

A. General

Refer to the schematics section.

This board conditions signals for the oxygen, pressure and flow sensors, plus the temperature and water-trap-full sensors. It also contains the drivers for the pneumatic valves and the sample pump.

B. Pressure and Flow

The board has two differential pressure transducers (XD1 and XD2) with two op-amp differential amplifiers (U6A and D; U6B and C). One transducer has a port removed, yielding a gage transducer system, used for monitoring patient airway pressure. The other is used differentially, to monitor pressure drop across a flow restrictor to allow the system to read sample flow.

Both transducers are nominally rated for one PSI, and have a nominal transfer ratio of 15 mV/PSI with a reference of 10V from the signal processor. The amplifiers have a gain of 333, yielding a final transfer ratio of 5 Volts/PSI.

The Service Screen indicates the voltages and values measured by these sensors.

CAUTION: Pressure in excess of 10 psi above atmospheric could damage the PAW transducer or sample system barometric pressure transducer in the RGM.

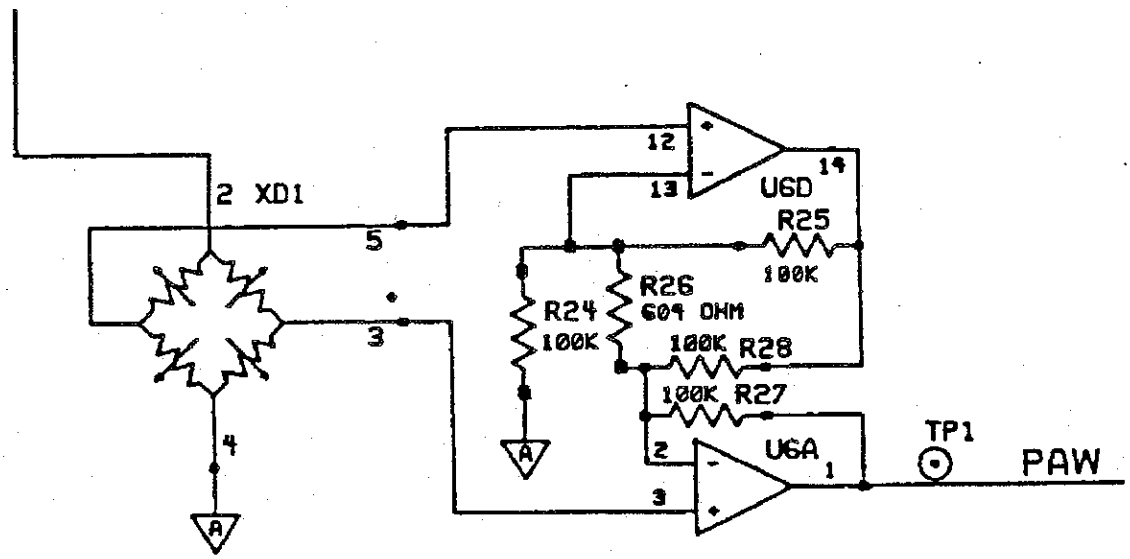


Figure 2-18. Pressure Transducer Amplifier
(From the Pneumatics Interface Board schematic)

C. Water Trap Full Sensor

The water level is sensed by a plastic rod with a conical end, which will reflect a light beam if the cone is in air. A narrow beam IR LED and phototransistor are PC board mounted in the separator block above the rod, along with the pull-up resistor for the phototransistor.

The sensing circuitry consists of:

- An adjustable 10 kHz square wave oscillator (U4A, R9, R19, and C9). R19 is adjusted to give maximum ac voltage output at U1B with no fluid in the bottle.
- An LED driver (via U4B-E and R8) that provides sufficient current for the infrared LED.
- A unity gain buffer (U1A) to keep the phototransistor from being loaded down.
- Inductor L1 that prevents dc offset changes due to changes in ambient light.
- A 10 kHz band-pass filter (U1B, C1, C2, R1, and R2)
- A charge pump type detector (C5, CR1, CR2, C10, and R10)
- A Schmitt trigger (U4F) to insure a valid logic level output (Trap Full) when the fluid collection bottle is full. A logic high corresponds to "water trap full status". The Service Screen indicates the status of the sensor.

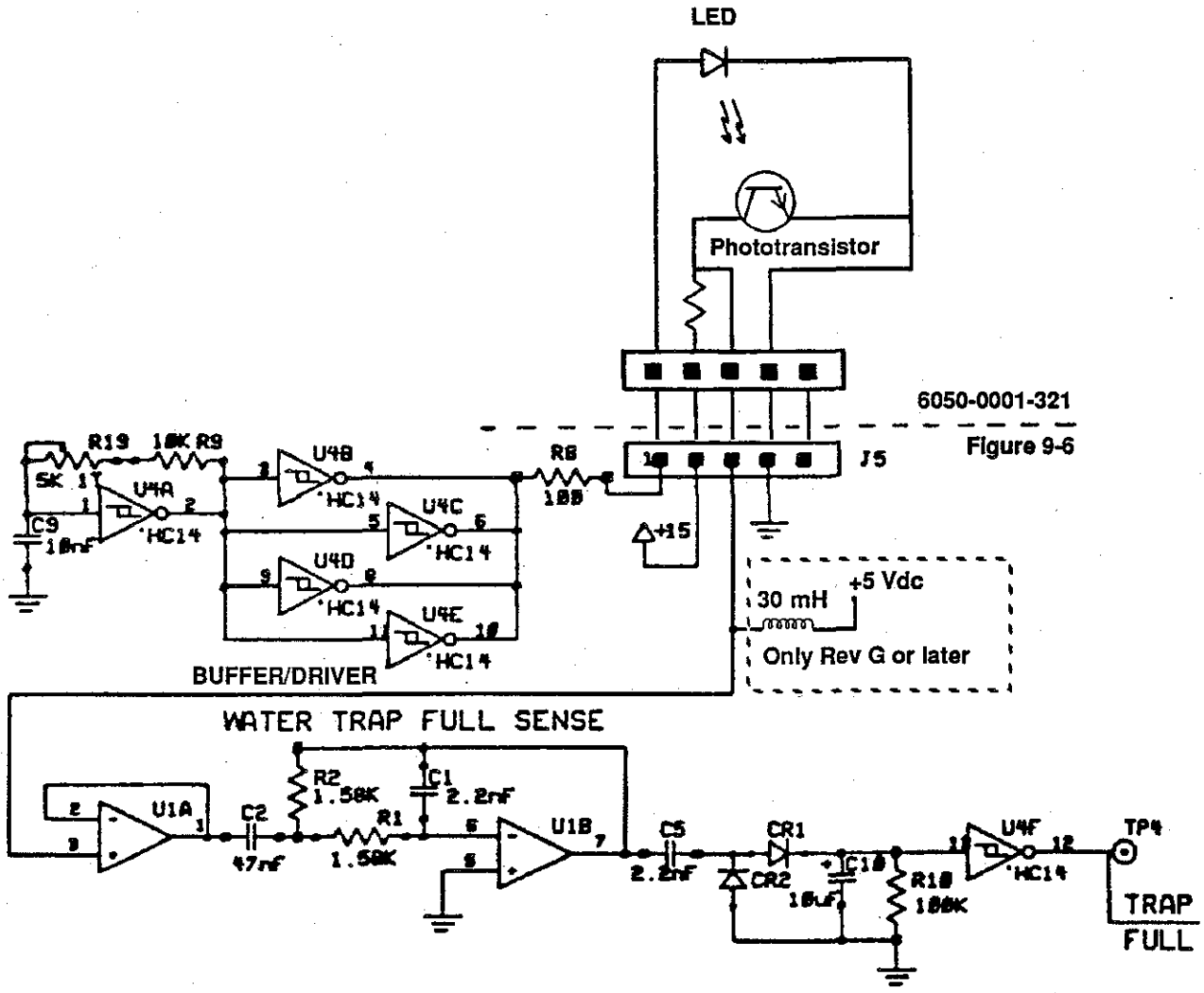


Figure 2-19. Water Trap Full Detector
(From the Pneumatics Interface Board schematic)

D. O_2 Amplifiers

The amplifier (U3A) for the circuit O_2 sensor has a load resistor of 681 ohms and a noninverting gain of 122. One side of the thermistor in the cell holder is connected to the cell anode, which is the ground of the amplifier circuit. The other side of the thermistor connects to the 49.9Ω resistor R14. This applies a temperature variable load to the cell in parallel with the 681Ω fixed load (R15). The 10V offset, applied through R34, shifts the signal to the full -10V to +10V range of the A to D converter. Thus -10V output is 0% O_2, also defined as no cell installed.

Note: The internal O_2 sensor amplifier has a similar configuration, using U3B.

The voltages, and values measured on the internal, and circuit O_2 sensors are identified in the Service Screen.

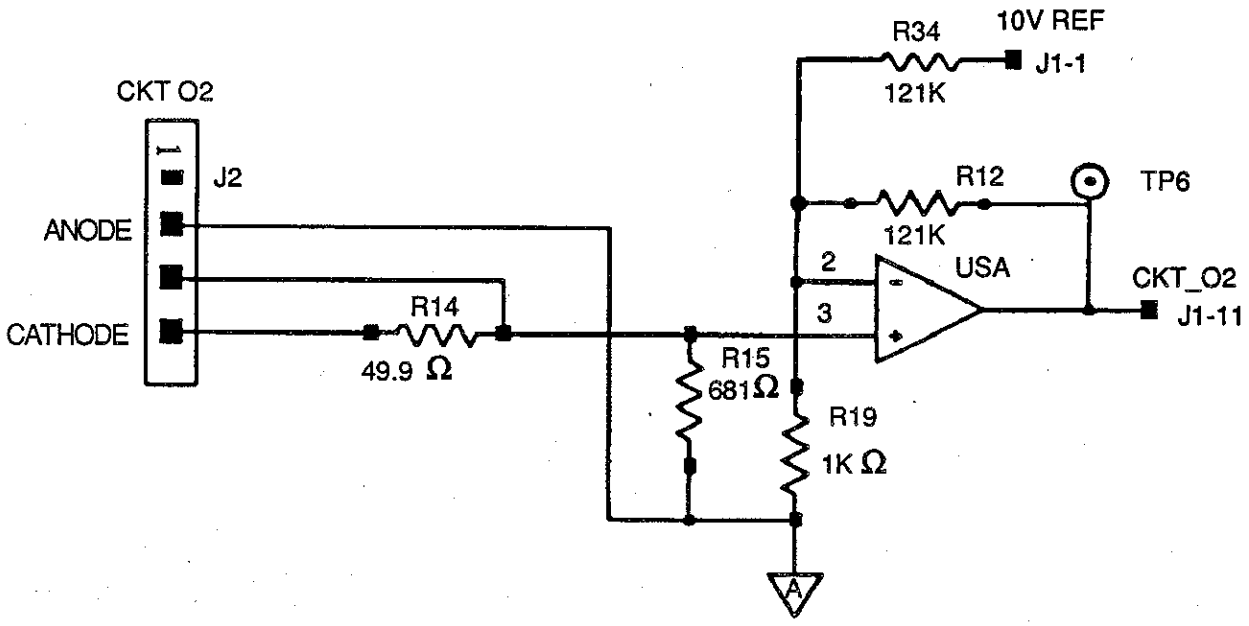


Figure 2-20. Circuit O_2 Amplifier
(From the Pneumatics Interface Board schematic)

E. Temperature

U2 is a temperature-controlled current source, with a transfer function of 1 uA/degree K. The current from the 10-volt reference through R6 offsets for room temperature (about 300 degrees K), and amplifier U5B yields a voltage output of 200 mV/degree, centered around approximately 28 degrees C.

The ten-volt reference of the temperature sensor comes from the ADC of the signal processor board.

The voltages and values measured by the temperature sensor are indicated in the Service Screen. This circuit is used to generate the DEVICE OVERHEATED alarm is the internal temperature of the RGM exceeds 50 degrees C.

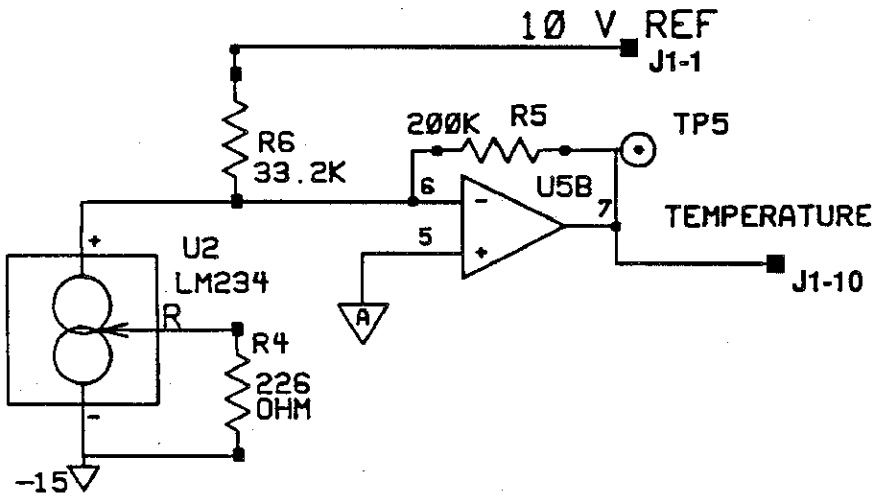


Figure 2-21. Temperature Circuit
(From the Pneumatics Interface Board schematic)

F. Solenoid Drivers

FETs Q2-Q5 switch the solenoid valves in response to logic level signals from the signal processor board. zener diodes CR5, 7, 9, and 11 provide voltage drop from the 15-volt supply, to the 12-volt solenoids. Diodes CR4, 6, 8, and 10 absorb any back EMF when the transistor is turned off.

Note: This board includes one spare solenoid valve driver.

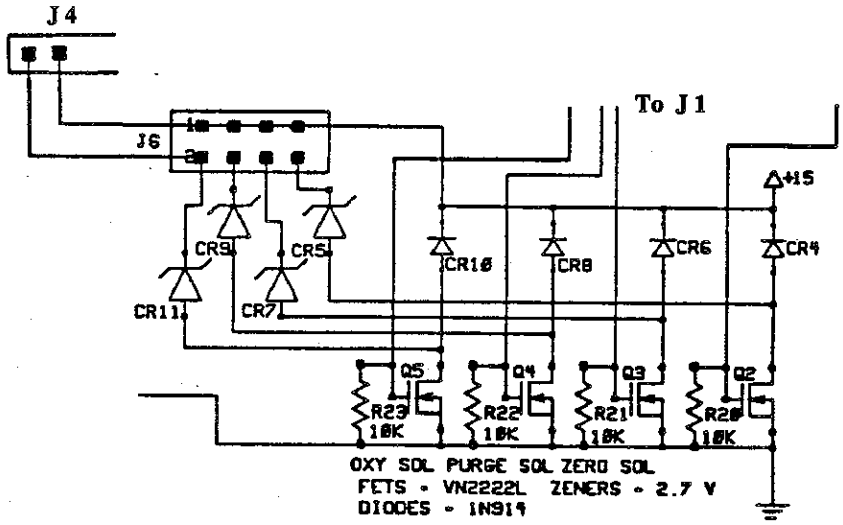


Figure 2-22. Solenoid Drivers
(From the Pneumatics Interface Board schematic)

G. Pump Driver

The gas sampling pump is operated by a variable voltage controlled by the signal processor. Transistor Q1 acts as a current buffer for unity gain amplifier U5A, which tracks the input control voltage. The transistor in the feedback loop of the op-amp eliminates the junction drop at the output. Diode CR3 insures a feedback path should the op-amp receive a negative input.

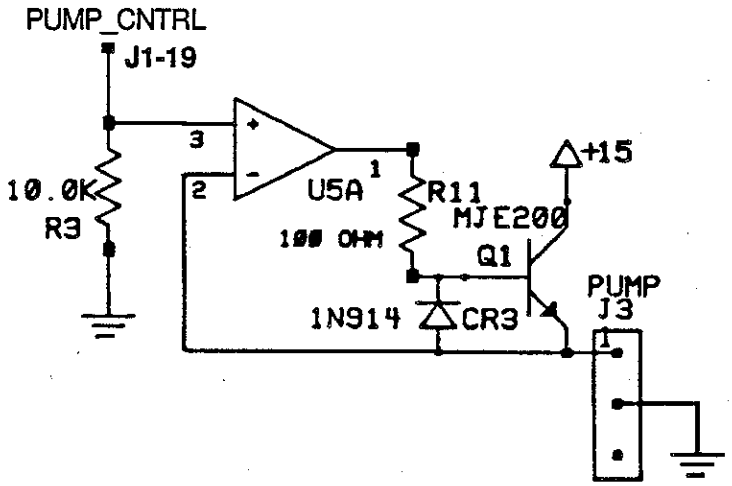


Figure 2-23. Pump Driver
(From the Pneumatics Interface Board schematic)

H. Test Points

The pneumatics interface board contains seven test points:

		Nominal conditions	Other conditions
TP1	P_{AW}	0 ±0.1 @ 0 cmH_20	6.5 ±1 @ 100 cmH_20
TP2	Analog ground	Ground	
TP3	Flow	3.5 ± .2 @ 230 ml/min	≈ 0 @ 0 ml/min
TP4	Trap full	0 (Empty)	≈ 5 Full
TP5	Temperature	0 ± 1 @ 28°C	
TP6	Circuit O_2	-7.0 to -8.5 @ 21% O_2	-2 to +8 @ 100% O_2
TP7	Internal O_2	-7.0 to -8.5 @ 21% O_2	-2 to +8 @ 100% O_2

2.6 Infrared Gas Analyzer

Note: Both analyzers (CX-104 and ACX-100) consist of a matched pair—a photometer and a measurement board. If replacement is ever necessary, replace them as a pair and not independently.

The infrared gas analyzer consists of:

Infrared photometer	In the photometer, a beam of infrared energy passes through the gas sample. An infrared detector measures the amount of energy absorbed.
Measurement board	Signal processing electronics demodulates the detector's output to acquire a DC signal, which corresponds to the content of each gas in the sample. For the CX-104 analyzer, analog signals for the gases and barometric pressure run through the mother board to the signal processor. For the ACX-100 analyzer, gas concentrations and barometric pressure values are passed as serial, digital data to the signal processor.

The measurement board plugs into the motherboard and the photometer mounts to the chassis behind the front access cover.

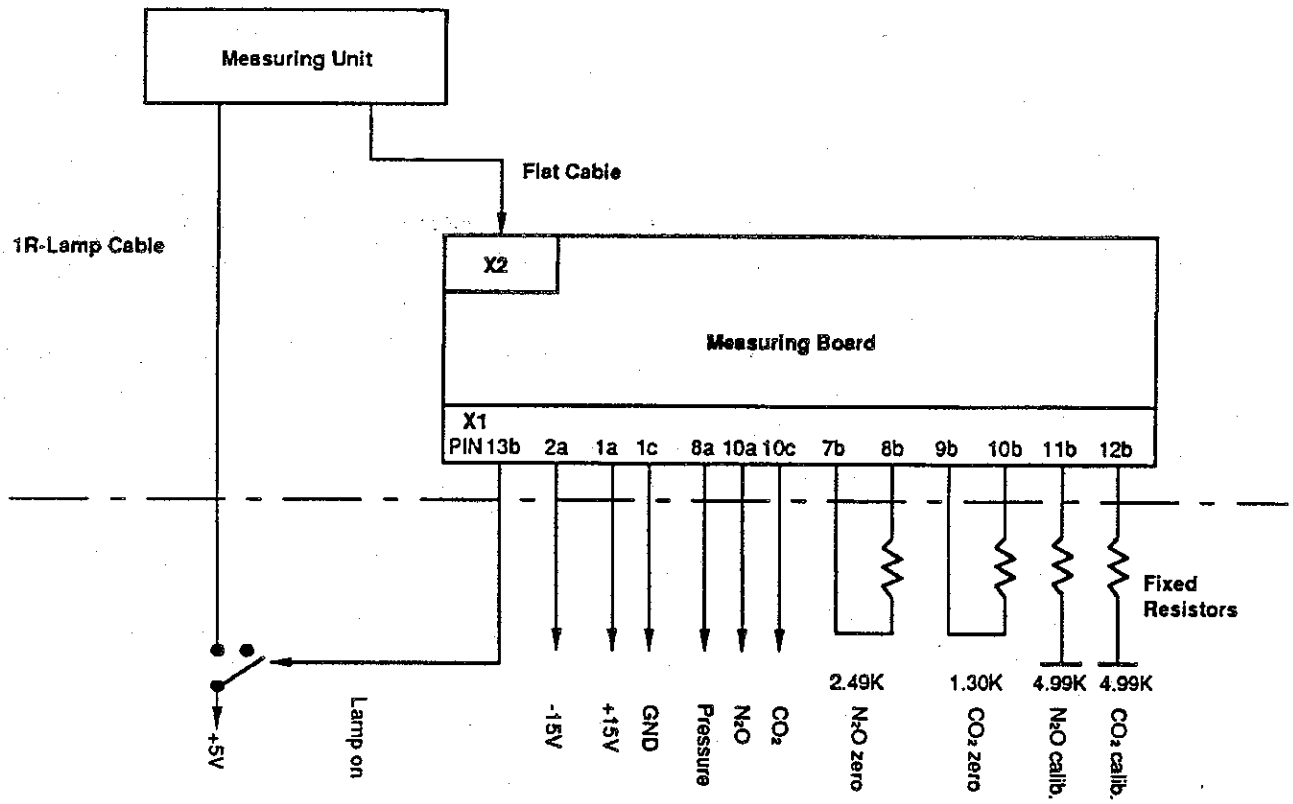


Figure 2-24. Gas Analyzer Block Diagram (CX-104)

A. CX-104 Infrared Photometer

The infrared photometer is a dual path type. The photometer detects infrared absorption through two separate cells of the measuring chamber: a reference cell and a sample cell. The reference cell is open only to the inside of the photometer, which contains a gas absorber box. The absorber insures that the reference cell is essentially free of CO_2 and N_2O, and agent for ACX-100. The sample cell is in series with the gas sample system. The sample gas is measured by determining the ratio between the light intensities of the reference and sample cells.

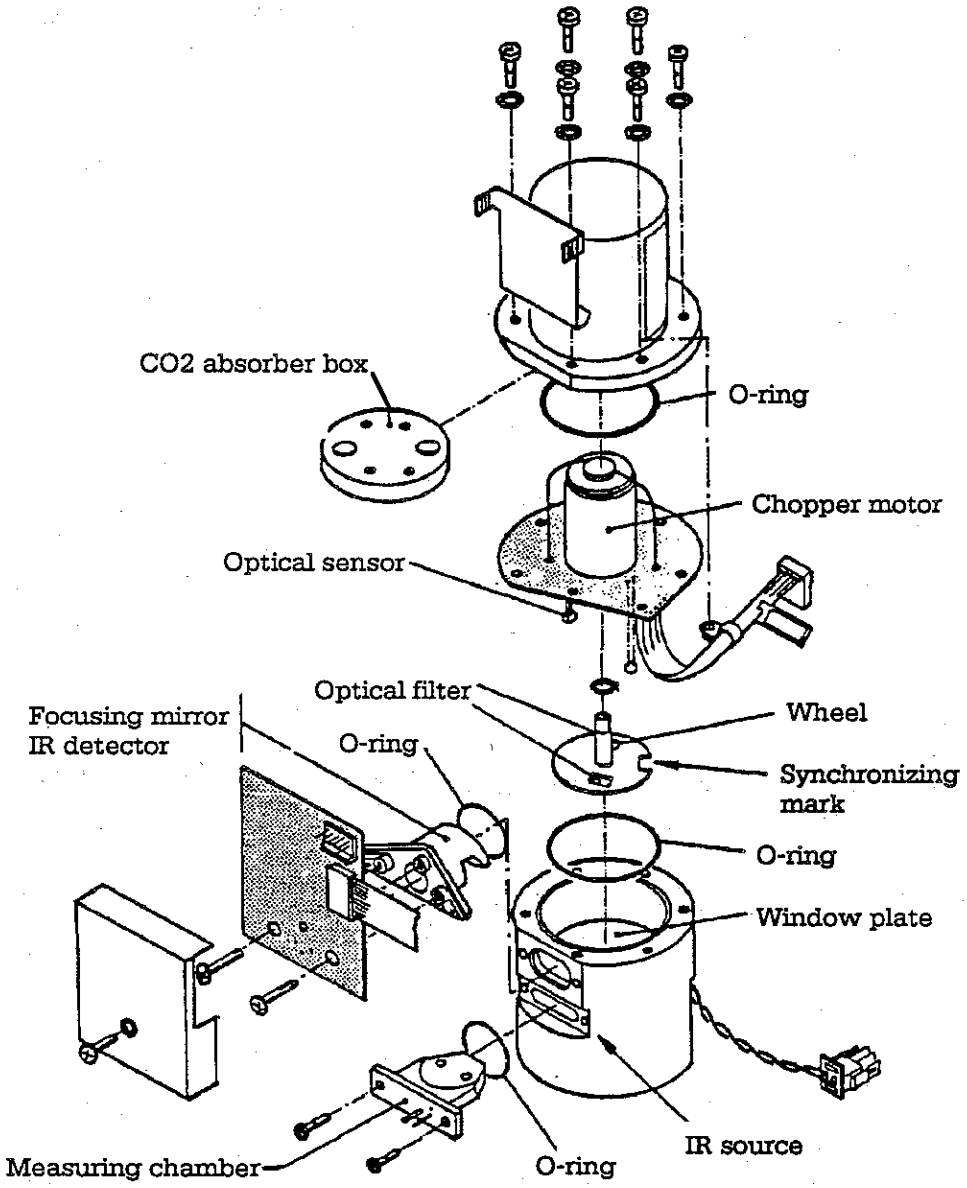


Figure 2-25. Infrared Photometer (CX-104 shown as example)

A filter wheel (chopper) controls the light passing through the photometer. For the CX-104 analyzer, two optical filters, one for CO_2 and the other for N_2O, are located on opposite (180-degree) sides of the revolving chopper wheel. For the ACX-100 analyzer, one additional optical filter is used for agent; therefore, the filters are spaced 120 degrees about the chopper wheel. The reference and sample cells are located one next to the other.

Infrared light first passes at the CO_2 absorption wavelength through the reference cell, then through the sample cell and then is blocked completely. This sequence is repeated for infrared light at the N_2O absorption wavelength. For the ACX-100 analyzer, this sequence is repeated for the agent absorption wavelength. For each revolution of the chopper wheel, this process produces five (or eight) light levels:

CO_2 reference	(Ref. CO_2)
CO_2 sample	(Meas. CO_2)
Dark	(Dark)
N_2O reference	(Ref. N_2O)
N_2O sample	(Meas. N_2O)

The ACX-100 analyzer uses three additional levels:

Dark	(Dark)
Agent reference	(Ref. Agent)
Agent sample	(Meas. Agent)

After passing the filters, the infrared light is focused by a mirror (part of the detector assembly) onto an infrared detector.

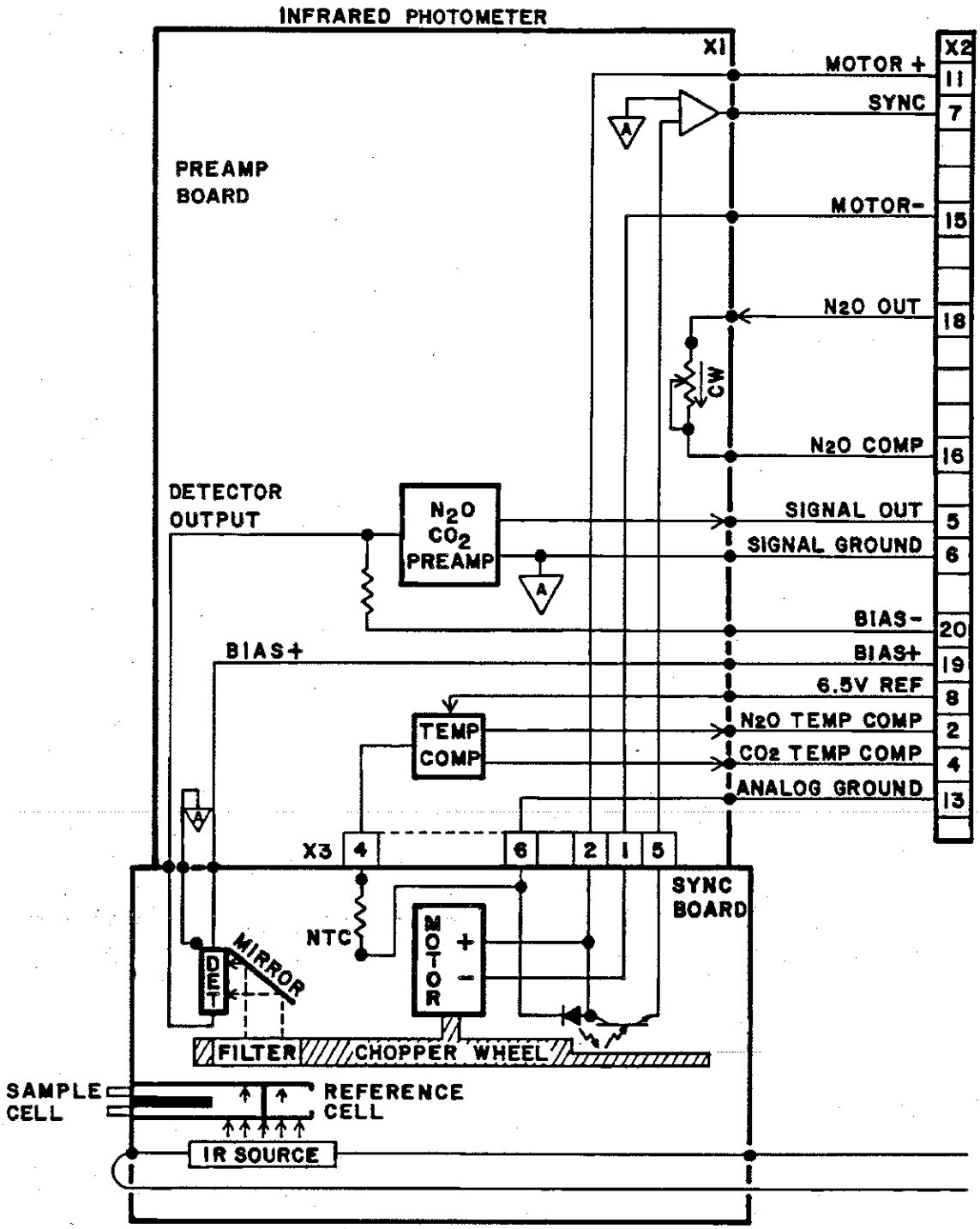


Figure 2-26. Photometer Block Diagram (CX-104 shown as example)

The chopper wheel also contains a reference mark at 90 degrees to both filters. A sensor in the photometer detects this mark once for every revolution of the chopper wheel. The pulses (SYNC pulse) from this sensor are used to synchronize the electronic circuits on the measurement board to the signals from the infrared detector.

To compensate for thermal drift, a thermistor (on the sync board) measures the temperature within the photometer.

Preamp Board (CX-104 description)

The preamp board (mounted on the photometer) amplifies the signals from the infrared detector, the timing sensor, and the thermistor, and converts them into a low impedance level. The amplifier for the infrared detector is a non-inverting op-amp.
The temperature signal from the thermistor is converted to voltage signal T+ by an inverting amplifier. This voltage is inverted to T- by another amplifier. With increasing temperature, T+ increases and T- decreases. The zero level of these voltages is set by R16 and the individual compensation signals for CO_2 and N_2O by R7 and R6, respectively.
The SYNC output pulse from the preamp board is generated from a current signal from the optical sensor.

Measurement Board (CX-104 description)

The functions of the measurement board are divided into four groups:
- Detector bias generator
- Timing electronics
- CO_2 measuring electronics
- N_2O measuring electronics

Detector Bias Generator (CX-104 description)

The infrared detector in the photometer is a lead selenide resistor whose resistance decreases in infrared light. The signal voltage from a resistive type device is directly proportional to the bias voltage applied across the resistive bridge. The bias generator increases the +15 volt supply voltage to approximately 22 volts.

The bias voltage generator is made up of one section of op-amp A8, connected as a square wave oscillator, and a voltage doubler made of diodes V6 to V9 and capacitors C34, C35, C37, and C38.

Timing Electronics (CX-104 description)

See Figure 9-25.

The timing electronics consists of a pulse shaping network made of three sections of op-amp A8 and logic circuits D3, D4, D5 D6, and D7.

The pulse shaping circuits receive the sync signal from the photometer (pin 7 of connector X2). The shaped sync pulse (pin 8 of A8) is used by the timing circuits.

The phase locked loop D6 outputs a frequency (pin 4 of D6) that is 40 times greater than the sync frequency. The output is divided down by counters D7 and D5 to reconstruct the original frequency. The outputs of these counters are decoded by multiplexers D3 and D4. The decoded outputs ("dark", "meas N_2O", "meas CO_2", "ref N_2O", and "ref CO_2") synchronize the measurement circuits to the various phases of the chopped output from the infrared detector.

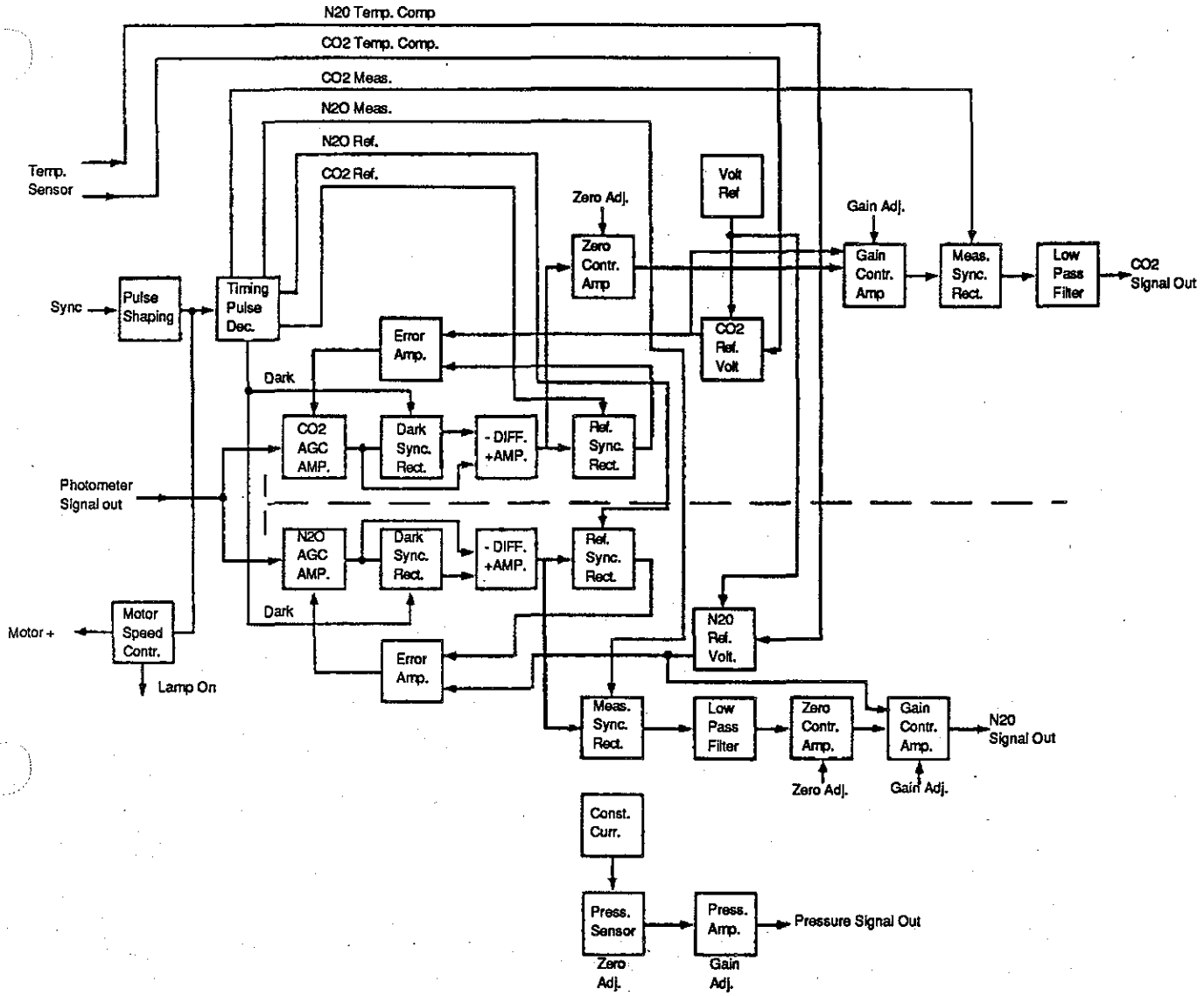


Figure 2-27. Measuring Board Block Diagram (CX-104 shown as an example)

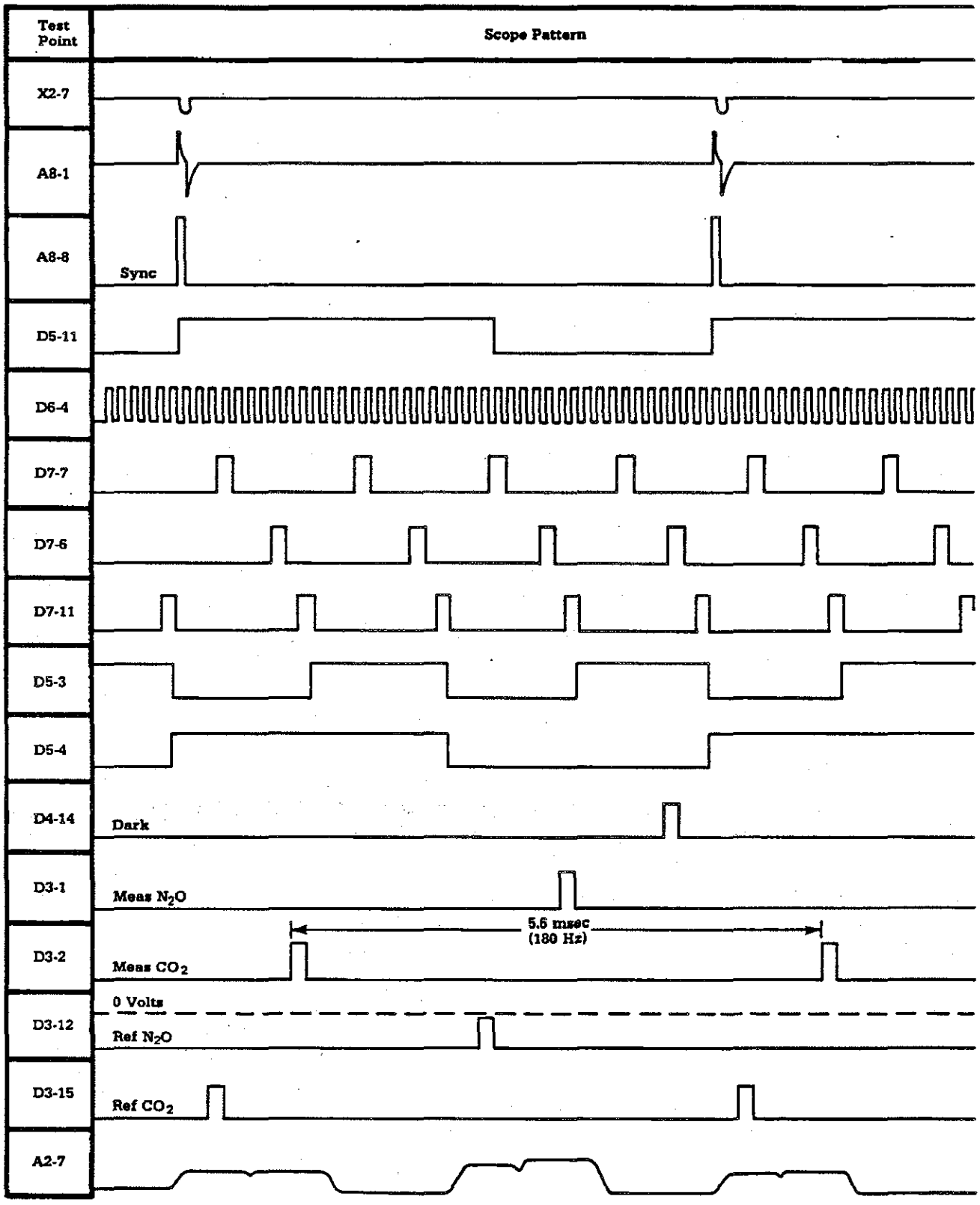


Figure 2-28. CX-104 Timing Diagram

CO_2 Measurement Electronics (CX-104 description)

The signal from the preamp comes into the measurement board through pin 5 of connector X2. The signal is first amplified by the "electronic potentiometer" circuit A4, one-half of which is used for the CO_2 automatic gain control.

From the output of this IC, samples of the dark phase are taken by an analog switch (1/4 D1) to capacitor C3. The dark level is subtracted by a differential amplifier (1/4 A2, R4 to R7) from the original signal so that at the output of this amplifier the dark level is locked to ground potential.

Another analog switch takes samples of the CO_2 reference level to C10. This voltage is compared to a standard voltage by 1/4 A2 whose output controls the gain of A4 and tends to keep the reference voltage equal to the standard voltage (6.5V).

The standard voltage originates from V2. To compensate for effects of temperature to the gain of the CO_2 measurement, a temperature dependent voltage from the photometer is connected to the summing point at A2 pin 10 to affect the standard voltage and consequently the gain of the AGC amplifier.

The signal from A2 output (pin 7) is connected through the zero adjustment potentiometer (X1 pins 9b and 10b) to an operational amplifier (1/4 A3), the gain of which is adjusted using the panel potentiometer and the rough adjustment trimmer R23, so that the standard voltage and the signal cancel each other at A1 input 3 when there is no CO_2 in the measuring chamber. The span of the CO_2 measurement is adjusted using R16 and the fine adjustment potentiometer connected between X1 pin 12b and ground.

The measuring phase of the signal is sampled by the analog switch (1/4 D1) and finally the DC signal is low-pass filtered to reduce noise and switching ripple.

N_2O Measuring Electronics (CX-104 description)

The N_2O measuring electronics is basically identical to the CO_2 electronics, so the above description applies to it as well. The only difference is that the measuring phase sampling and low-pass filtering in the N_2O circuit take place before the zero and gain adjustment circuits. The reason is that the longer time constant of the filter would otherwise cause difficulty in the adjustments.

Motor Speed Control Circuit (CX-104 description)

The speed of the chopper motor is stabilized by the circuit consisting of a one shot and an integrator/comparator. The pulses from the timing electronics trigger the one shot at a frequency that corresponds to the speed of the motor.

The output pulses from the one shot are fed into the integrator/comparator. The voltage at the output of this circuit depends on the difference between the mean of the pulse train and the DC voltage at its other input. This voltage is inverted and used to control the transistor V14, which in turn drives the chopper motor. The circuit tends to keep the duty cycle of the pulse train constant, and consequently stabilize the speed of rotation of the motor. The transistor V15 limits the motor current to approximately 50 mA.

Pressure Electronics (CX-104 description)

The absolute pressure transducer is supplied with 4 mA constant current by the circuit consisting of two sections of A9 and transistors V10 and V11. The current is derived from the 6.5V constant voltage, which is first converted to 4 mA current from +15V to ground by the first section of A9 and the transistor V11. This current causes a 4V voltage drop in R98, which is then converted to 4 mA current in the other op-amp transistor circuit.

The pressure transducer is based on a piezoresistive bridge having a full-scale output voltage of approximately 400 mV. The resistors R1P and R2P set the zero temperature compensation of the transducer. R3P and R4P set the offset voltage. The output voltage is first amplified with a differential amplifier with a gain of approximately 7 and then with an inverting

amplifier whose gain is adjustable with R47. Also connected to this amplifier is the offset adjustment potentiometer R46.

Lamp Control Circuit (CX-104 description)
The infrared lamp is supplied with a 5 Vdc regulated supply voltage. If the filter wheel stops spinning, the supply voltage to the IR lamp is switched off to avoid damaging the filter wheel. (See Chapter 2 "Power Supply Board, Frequency Monitor" for a functional description.)

B. ACX-100 Measuring Board

CAUTION: Do not attempt to repair or replace the photometer pressure transducer (B1). Each pressure transducer is specifically calibrated with selected resistors for use on a given board.

The measuring electronics can be divided into a few functional blocks, which are described as follows (see the block diagram):

The ACX measurement board controls gas measurements. It converts the photometer signal to digital data, calculates results and transmits it to main CPU board. The board contains, in addition to the 80C51FA processor, EPROM, RAM, and EEPROM, several analog and digital I/O functions. It passes these values as serial data to the signal processor board.

Infrared Photometer
The infrared photometer is a dual-path type. The photometer detects infrared light absorption through two separate cells in the measuring chamber: a reference cell and a sample cell. The sample gas is measured by determining the ratio between the intensity of infrared light that is transmitted through the reference cell and through the sample cell.

The two cells are located next to each other. The sample cell is in series with the gas sample system; the reference cell is open only to the inside of the photometer. The photometer contains a gas absorber that ensures that the reference cell is essentially free of CO_2, N_2O, and the agent.

A revolving disc, or wheel, located between the measuring chamber and the detector, controls the light passing through the photometer. Three optical filters are located around the outer edge of the wheel. They are spaced 120 degrees apart and are in line with the sample and reference cells. Each filter passes a specific wavelength of infrared light that is associated with each gas to be measured (CO_2, N_2O, and agent).

Infrared light first passes at the CO_2 absorption wavelength through the reference cell, then through the sample cell, and then is blocked completely. This sequence is repeated for infrared light at the N_2O absorption wavelength and then the agent absorption wavelength.

After passing through the filters, the infrared light is focused by a mirror (part of the detector assembly) onto an infrared detector. The detector measures the light levels for each gas. For each revolution of the wheel, this process produces six light levels specific to the gas content (two for each gas) and a baseline reference signal (one for each gas) when the infrared light is completely blocked off (Dark).

Gas	Light Level
CO_2	
Reference	(Ref. CO_2)
Sample	(Meas. CO_2)
Dark	(Dark)
N_2O	
Reference	(Ref. N_2O)
Sample	(Meas. N_2O)
Dark	(Dark)
Agent	
Reference	(Ref. Agent)
Sample	(Meas. Agent)
Dark	(Dark)

The reference and sample cells are located next to one another so that the leading edge of the filters passes over the reference cell first, and the trailing edge of the filters passes over the sample cell last. The leading portion of the resulting waveform is associated with the reference cell; the trailing portion is associated with the sample cell.

An optical sensor in the photometer detects light from a reflective surface on the wheel once every revolution. The pulses from this sensor synchronize the electronics on the measurement board to the signal from the infrared detector.

A thermistor measures the temperature within the photometer to compensate for thermal effects.

The infrared detector, optical sensor, and stabilizing diode are mounted on a preamplifier board, which is an integral component of the photometer. This board amplifies the signals from the detector, the sensor, and the thermistor, and converts them to a low impedance level before routing them to the measurement board for further processing.

An EEPROM in the photometer is programmed with parameters specific to that photometer. The measurement board uses these parameters to adjust its circuits for that specific photometer.

Under normal operation, the measurement board supplies a signal (lamp) to the motherboard, which controls power to the infrared source. If the measurement board fails to receive the expected signals from the photometer, it assumes that a photometer failure may have caused the wheel to stop spinning. It removes the lamp signal to avoid overheating and damage to the wheel.

Internal and External Bus (ACX-100 description)

The processor D1 has access to the measurement board peripherals (memory, A/D converter, D/A converters, etc.) via an internal bus. For communication between the CPU board and the measurement board, there is an external bus in connector X1. The external bus is driven by D21 (data lines), D3 (address lines) and D18 (read and write lines).

Memory (ACX-100 description)

Memory components include 64 x 8K bit program memory EPROM (D4), 32 x 8K bit low current CMOS RAM (D22) powered by a RAM Upgrade Kit (6050-0002-022) or a jumper on the motherboard, and EEPROM (D2) for permanent calibration values and setup memory.

Reference Voltages (ACX-100 description)

Reference voltages are established by the A/D converter (D14) reference voltage output (REFOUT, pin 8). This +10 V voltage is buffered by A2D. -10 V reference voltage is obtained by inverting and buffering +10 V with amplifier A2C.

Measuring Electronics for CO_2, N_2O, and AA (ACX-100 description)

CO_2, N_2O, and anesthetic agent measurement is accomplished by measuring each of these gases from the reference and measuring chambers of the ACX-100 photometer. The gas signals are transmitted from the ACX-100 photometer assembly through connector X2 pin 2 of the ACX measuring board and applied to the reference input of a D/A converter (D8). D8 is controlled by the microprocessor and is used for automatic gain control. The output current from D8 is proportional to the incoming signal and the gain is established for each gas, (CO_2 reference and measuring, N_2O reference and measuring, and AA reference and measuring) by software.

The signals are converted to a voltage by A24D and amplified by A24A, then applied to capacitor C30, which removes the DC offset. The dark level is established on C30 when the synchronous switch A28A is closed.

Each signal is sampled by the peak detection circuit, consisting of A24C, V26, A28B, R97, R201, and C15. When the peak voltage of a signal is sampled, the switch A28B is open, sending the signal through V26, which acts like a diode. The peak signal is then applied to the capacitor C15. C15 is brought down to ground potential between signal peaks when A28B is closed and the dark signal is transmitted to it.

The voltage peak of each gas (both measure and reference) is applied to an instrumentation amplifier (A24B) then to the input of a multiplexer (D23). D23 separates the signal to each of its components, (CO_2 reference and measuring, N_2O reference and measuring, and AA reference and measuring). For CO_2, the offset voltage is subtracted from the reference signal at A13B.

Each gas signal, the temperature compensation signal and the pressure signal are transmitted to D13, which serves as a demultiplexer whose output is applied to an A/D converter (D14) through an instrumentation amplifier.

A/D Conversion (ACX-100 description)

A/D conversion is made with a 12-bit A/D converter (D14). Input signal is multiplexed with D10 and D13. After conversion is completed, signal ADCRDY rises to +5 V.

D/A Conversion (ACX-100 description)

D/A Conversion is made with a 12-bit D/A converter (D11). D12 multiplexes the analog output to 8 sample and hold circuits. Two of these are used to drive offset voltages for N_2O and CO_2 measurement. The others are used for external analog outputs (CO_2,OUT, N_2OOUT, VOLC, O_2OUT, etc.).

Timing of CO_2, N_2O, and AA signals (ACX-100 description)

A timing pulse is produced when light is reflected to a phototransistor from a reflectorized surface on the filter wheel. The pulse produced is shaped by A28 on the preamplifier board and transmitted to port 3 of the microprocessor on the ACX measuring board.

The processor produces the necessary address information to cause the PAL (D15) to produce the control pulses for the synchronous switches A28A and A28B (Dark and Clear).

Motor Speed Control (ACX-100 description)

The speed of the stepper motor in the ACX-100 photometer is controlled with MOTOR-signal from the processor. This signal is buffered by D6.

Pressure Measurement (ACX-100 description)

CAUTION: Do not attempt to repair or replace the photometer pressure transducer (B1). Each pressure transducer is specifically calibrated with selected resistors for use on a given board.

The pressure transducer (B1) measures the sampling system pressure after the photometer. Voltage reference V1, resistors R17, R108, R89, and amplifier A31C supply the pressure measurement bridge with 4 mA current. The pressure signal is amplified with A31A and A31B. The output of A31A corresponds to pressures 400 to 900 mmHg and is within -9.5 V and +9.5 V range.

Temperature Measurement (ACX-100 description)

Temperature measurement exitation voltage for photometer stabilizing diode is fed from +10 V through resistor R104. The stabilizing diode voltage is proportional to photometer temperature. This voltage is amplified with A31D.

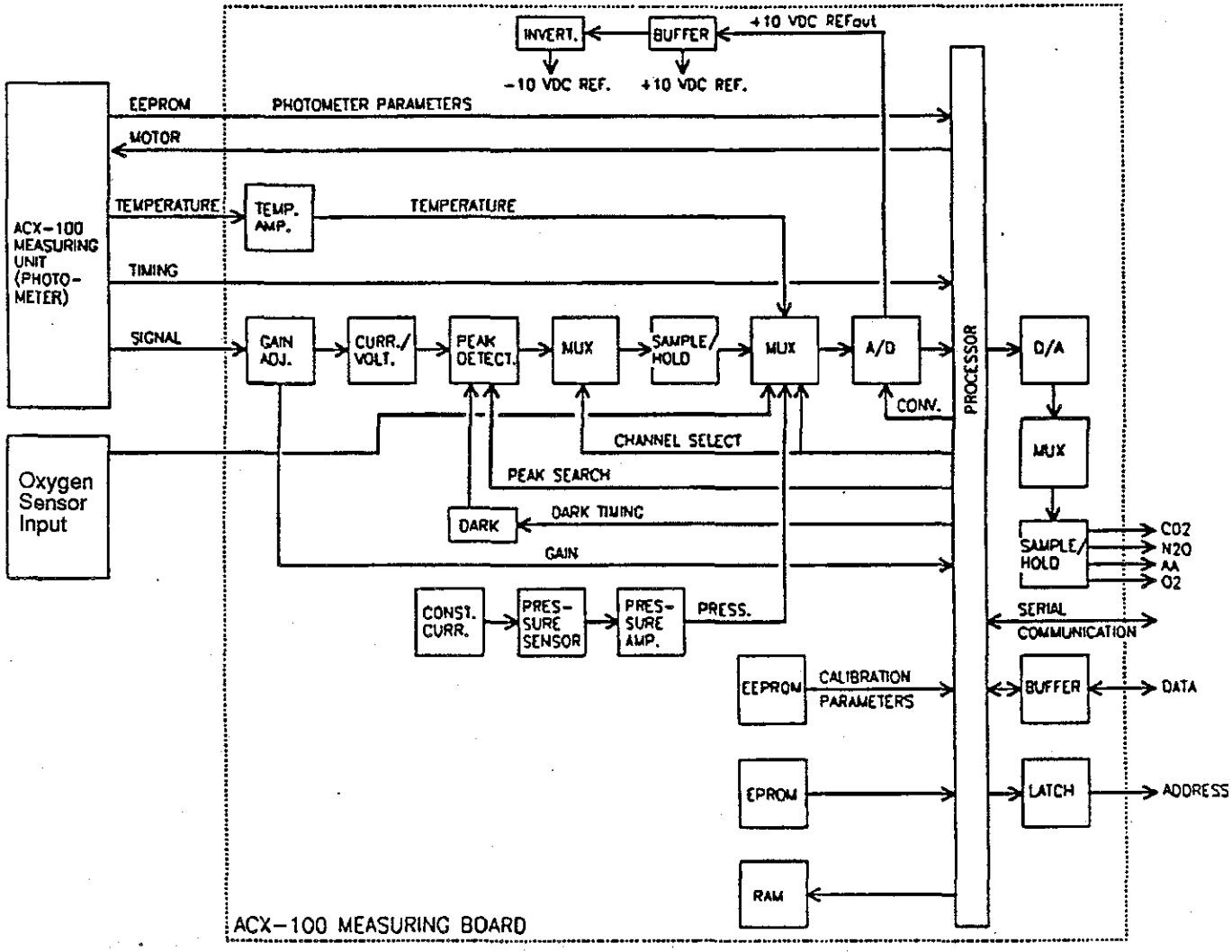


Figure 2-29. ACX-100 Measuring Board Block Diagram

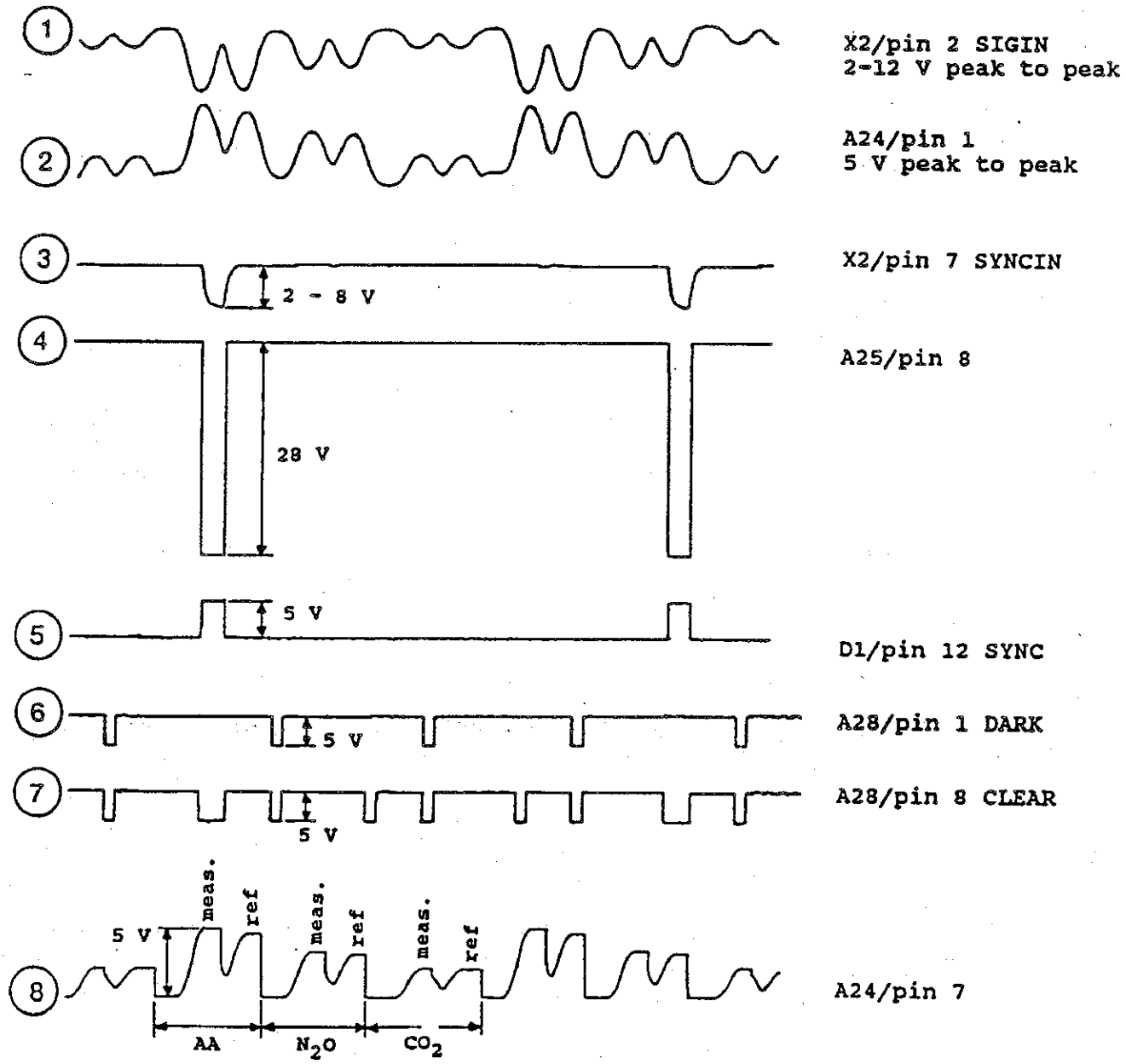


Figure 2-30. ACX-100 Measuring Board Timing Diagram (board modification level 7 and higher)

2.7 Signal Processor Board

A. General Description

Refer to the schematics section.
The signal processor board is a general purpose computer for analog acquisition, signal processing and communications. It features a sixteen-channel analog multiplexer feeding a twelve-bit ADC, and eight DACs with 8-bit resolution. The board includes four channels of serial I/O.

B. Microprocessor

The microprocessor (U13) is a NEC V25 integrated processor with parallel I/O (32 lines, shared with other functions), two serial I/O ports with independent baud rate generators, two timers, and an interrupt controller. The crystal frequency is 10 MHz, which gives a 5 MHz system clock on CKOUT, P0 bit 7. With processor boards revision G or greater, the NEC V25+ is used and the crystal is changed to 14.3181 MHz. This change gives the processor board more processing capability. The software (revision 2.04 or greater) can identify, which processor is installed and set internal timing appropriately for their respective crystal frequency.

The parallel port pins are used for system configuration, oximeter (MINX) interfacing, TVX clip interfacing, and analog input multiplexer control.

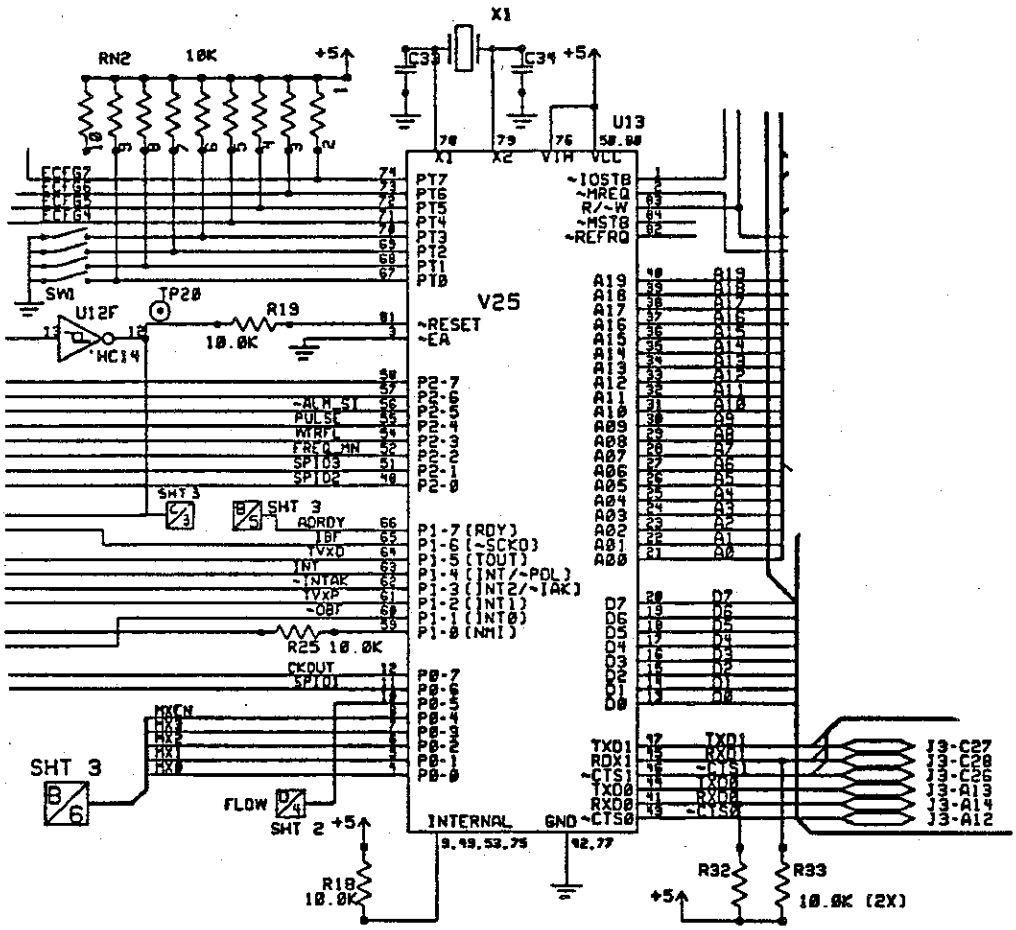


Figure 2-31. Microprocessor Circuit
(From the Signal Processor Board schematic)

C. Memory

Memory consists of two static dip package memory locations (U7 and U8) and a ROM card (U6). Dip socket (U8) is connected to a lithium battery for non-volatile RAM, and the other is normally a second (optional) RAM, but can be jumpered (with trace cuts) to be ROM. Either may be 28-pin (up to 32K bytes RAM or 64K bytes of ROM) or 32 pin (128K byte).
The ROM card can hold one or two chips. The chips may be either 32K bytes or 64K bytes. The ROM card is replaceable without removing the board from the RGM.

Note: Never power up the unit with the ROM card removed.

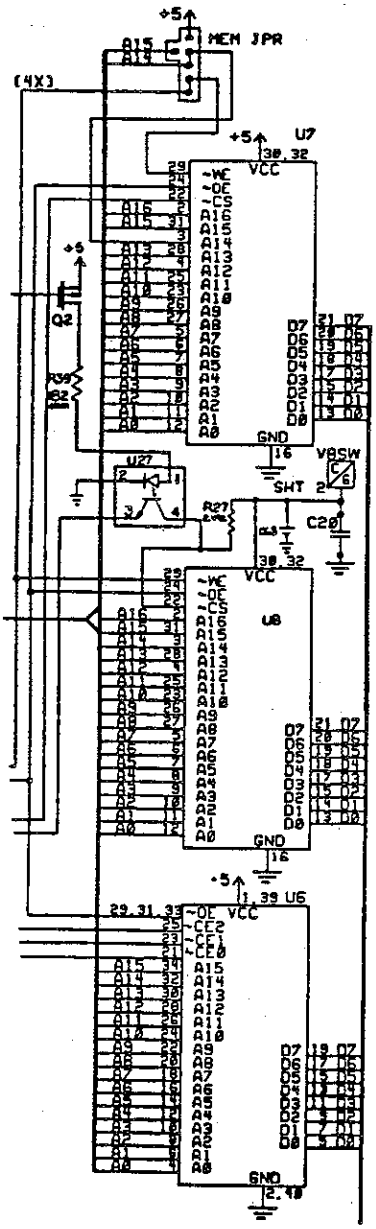


Figure 2-32. Memory

(Details of implementation have changed over time, refer to the Signal Processor Board schematic for specifics.)

D. Decoding

Two programmable logic chips (PALs U14 and U16) perform the external I/O decoding, using simple combinatorial logic upon address and processor control lines to enable the I/O functions. Another PAL (U24), which is socketed, performs the same functions for memory accesses.

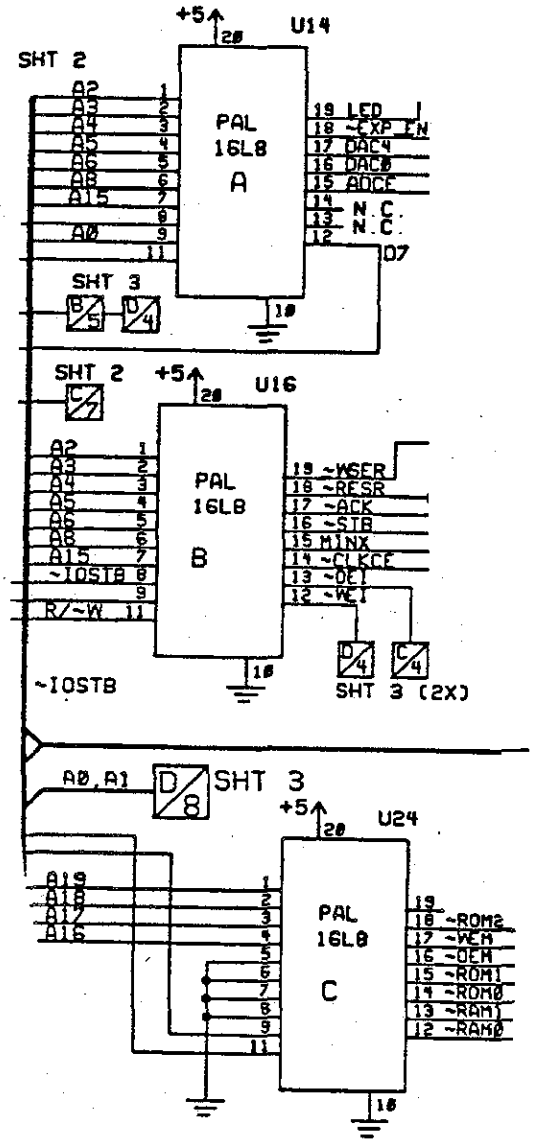


Figure 2-33. Decoding PAL

(Details of implementation have changed over time, refer to the Signal Processor Board schematic for specifics.)

E. Watchdog

The watchdog chip U18 requires pulses every 50 mS on its watchdog input (WDI) to inhibit an auto reset function. These pulses are output on P2 bit 7 of the V25 CPU. A watchdog fail reset may be seen when bit #8 (see Section 2.7K, Status LEDs) is lit.

This chip also has a power fail comparator and reference, which monitors PWR MON on its PFI pin. This comparator outputs a signal to the CPU nonmaskable interrupt (P1 bit 0) if the voltage falls below 1.3 volts. The monitored signal from the power supply will allow operation for at least 12 mS after this threshold has been passed.

This circuit also contains a lithium battery (B1), which supplies power to the Vout pin if Vcc falls below the battery voltage. This powers the time of day clock (U23) and the nonvolatile memory (U8). When Vcc falls below 4.65 volts (±0.1 volt) two other signals, PDCTL and LO_V disable U8 and U23 respectively. **On revision H (or later) signal processor boards, two alternate control lines, RESET and ~RESET, are used for U8 and U23.**

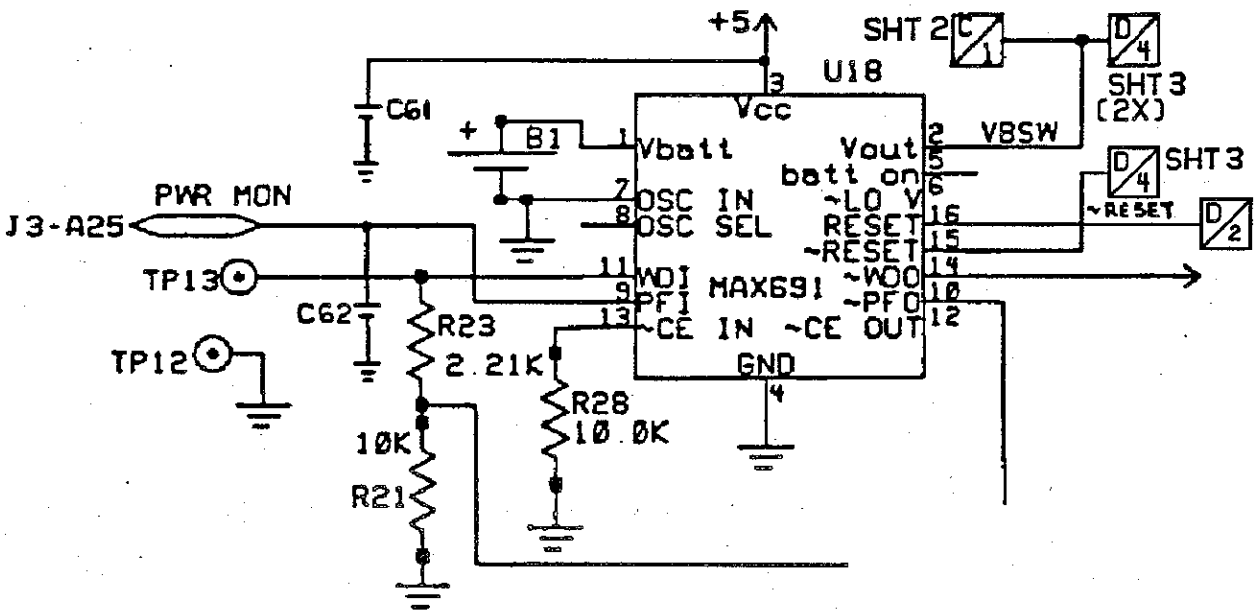


Figure 2-34. Watchdog Circuit (Rev H and later)
(From the Signal Processor Board schematic)

F. Configuration Input Switches

The V25 port labeled PT on the schematic is for input only and features an adjustable threshold. It is used to identify the system configuration with four switches for option status (refer to the checkout procedure in Chapter 3 for more detail).

Dip Switch	Position	Indication
1	Closed (ON)	Oximeter board not installed.
	Open (OFF)	Oximeter board installed.
2	Closed (ON)	Normal position (this switch is not used). TVX enabled for Rev 3.0.
	Open (OFF)	TVX disabled for Rev 3.0.
3	Open (OFF)	Calibration constants are locked.
	Closed (ON)	Calibration constants are unlocked.
4	Closed (ON)	Normal position (this switch is not used).

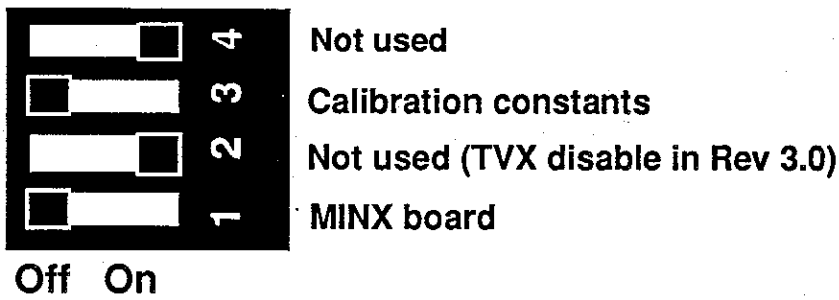


Figure 2-35. SW1 Signal Processor Configuration Switch

G. Analog Acquisition

Fifteen external signals plus internal test signal (ATEST) are multiplexed by IC U20. The enable signal (MXEN) outputs the signal, selected by MX0-3, which is then stored by capacitor (C49) while the voltage level is converted by the analog to digital converter AD674 (U19). This capacitor is buffered by a fast, low bias current op amp (U22) to prevent loading by U19.

The analog to digital converter (ADC) converts the voltage and sends the data to the processor as two bytes. The input range is ±10 volts, for a scale factor of 4.88 mV/bit. The converter reference is buffered by op-amp U21 and output to the pneumatics interface board.

The multiplexer channel is controlled by the V25 P0 bits 0 to 3, and enabled by P0 bit 4. The conversion starts by executing an I/O write to 1CH. Conversion complete is tested on P1 bit 7 where a 1 indicates conversion is in process. Data is then read at two successive addresses in I/O memory.

RGM analog input assignments

Test Point	Code	Function	Test Point	Code	Function
TP19	0	Barometer*	TP16	1	MINX pleth
TP17	2	CO_2*	TP18	3	N_2O*
TP3	4	Flow	TP1	5	P_{AW}
TP4	6	Int. O_2		7	Ext. O_2
	8	DAC Loop back		10	Temperature

* These voltages appear only with the CX-104 (non-agent) system.

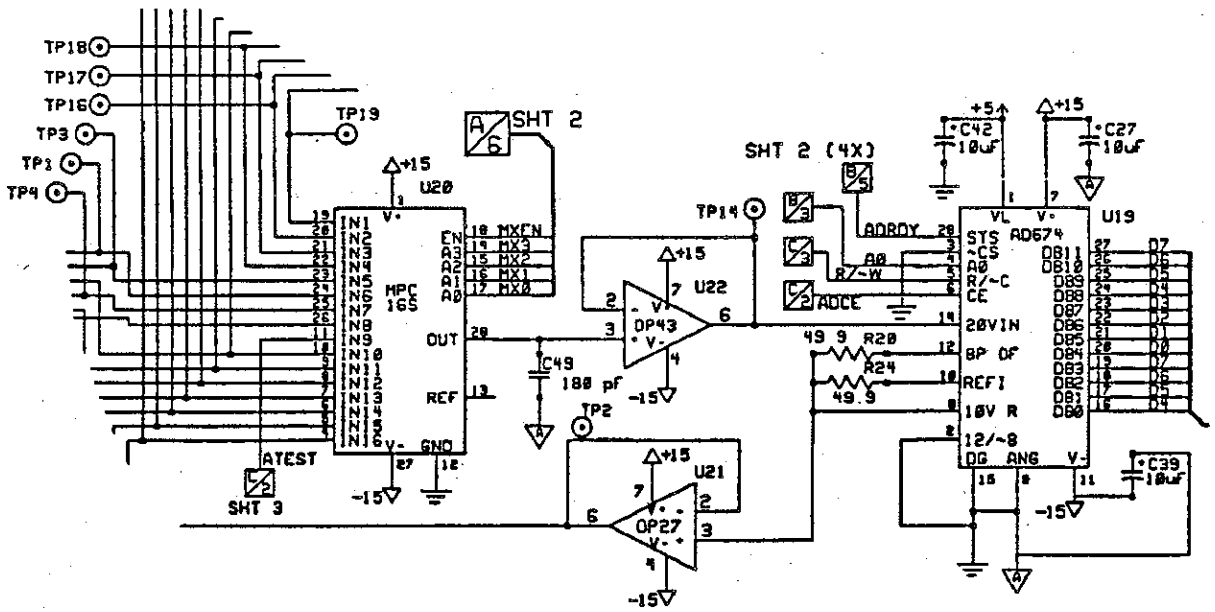


Figure 2-36. Multiplexer and A/D Converter
(From the Signal Processor Board schematic)

H. Analog Output

The board has two eight-bit DACs U10 and U15. Each DAC has four voltage outputs. The DACs share a 10-volt reference: IC U9.

Of the eight voltage outputs, seven are divided by ten, R9-R15 and R2-R8, providing the general purpose analog outputs with a zero-to-one voltage range.

Channel 6 is also routed, to the analog input multiplexer U20 as a test signal (ATEST).

Channel seven is buffered by a unigain op amp and routed to the pneumatics interface board as a variable pump drive signal (PUMPB). Each output is unity buffered by op-amps U4 and U5. Capacitors C3, 10, 12, 5, 6, 13, and 15 prevent DAC glitches from appearing at the outputs.

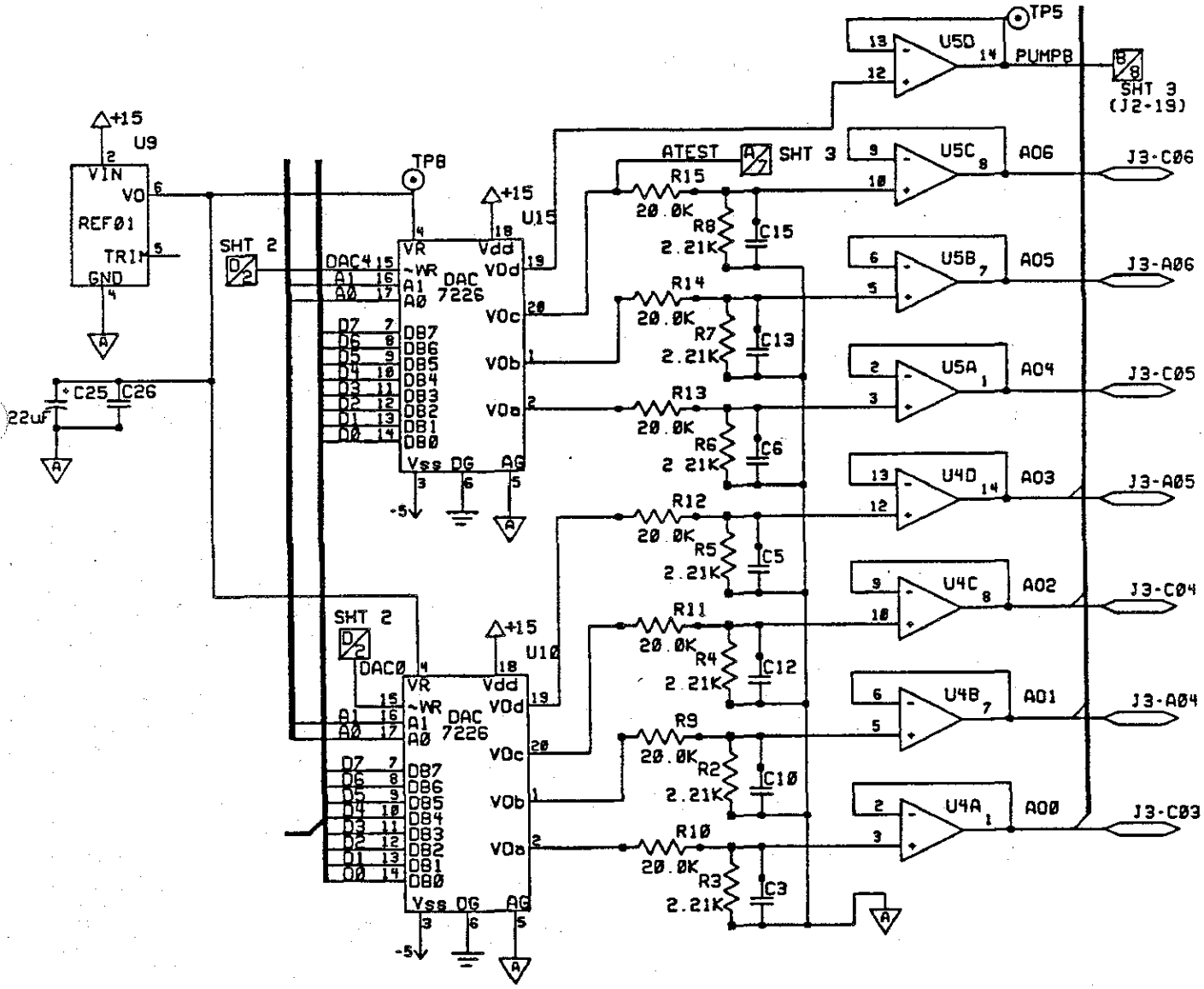


Figure 2-37. DAC Outputs
(From the Signal Processor Board schematic)

I. TVX Interface

The TVX connects to the microprocessor through Schmitt buffers U12A (TVXA) and U12B (TVXB).

TVXB goes to interrupt line (INT1), where it can either directly interrupt the processor or generate a macro service call to store the time of the event in a buffer. The other bit for direction sensing may be read at P1 bit 5. The interrupt bit may be read at P1 bit 2.

J. SpO_2 Oximeter (MINX) Interface

The decode PAL U16 decodes an address and the read/not write (R/~W) signals from the processor, and generates the enable signal (MINX), which with R/~W control bidirectional buffer U17. It also generates ~STB (for data OUT to the oximeter) and ~ACK (for data IN from the oximeter), which coordinate the transfer of data.

The processor reads ready status (IBF and ~OBF) at P1 bits 6 and 1 respectively. ~OBF may also generate and interrupt (INT0) to insure timely reception of data from the oximeter. Saturation data and the oximeter status/control information occur through the parallel interface provided by the bus transceiver U17.

A patient pulse signal from the oximeter is received at P2 bit 4 as a short (about 16 mS) logic pulse, which software must sample regularly to sense. This signal triggers the pulse beep.

The ADC reads the patient plethysmograph, which is then sent to the display.

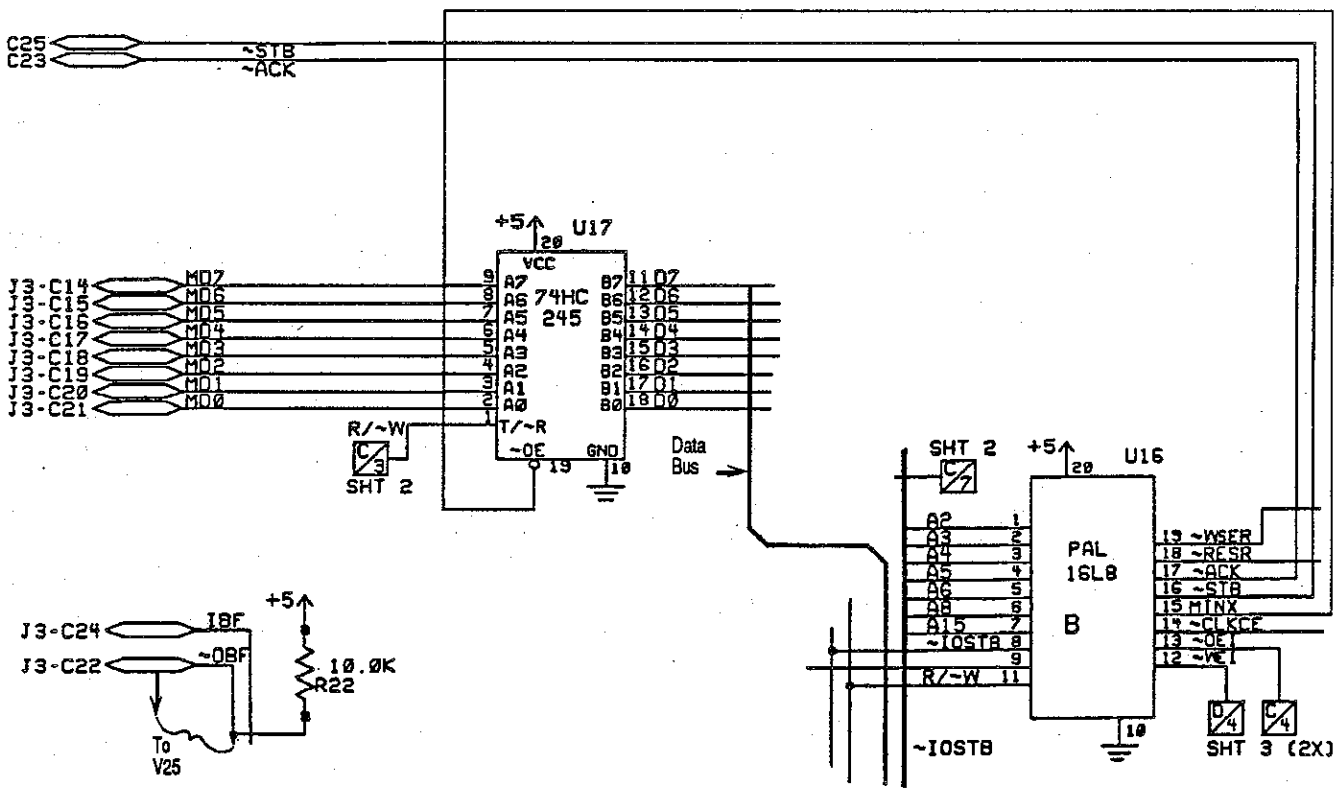
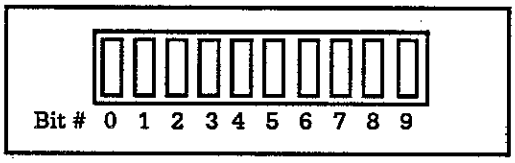


Figure 2-38. Oximeter (MINX) Interface
(From the Signal Processor Board schematic)

K. Status LEDs

A 10-LED bar chip (U1) indicates the software and system status. Also see Figure 6-5 for LED bar status during powerup.



Bits	Status
0-4	General software status Bits 0-3 are CO_2 breath phase bar graph. Bit 4 is PAW breath phase.
5	Oxygen solenoid
6	Purge solenoid
7	Zero solenoid
8	Watchdog failure
9	Spare solenoid valve

L. Serial I/O

In addition to the serial ports on the microprocessor, a dual channel multimode IC (U11) provides independent baud rate generators, and operates in asynchronous or synchronous modes. This device drives the external RS-232 port. It is addressed in I/O space. The timing signal (CKOUT) for U11 comes from the V25 clock out labeled P0 bit 7. With PCA revision H, the reset line of U11 is software controlled from the V25 pin, P0 bit 6, which is buffered through inverter U12.

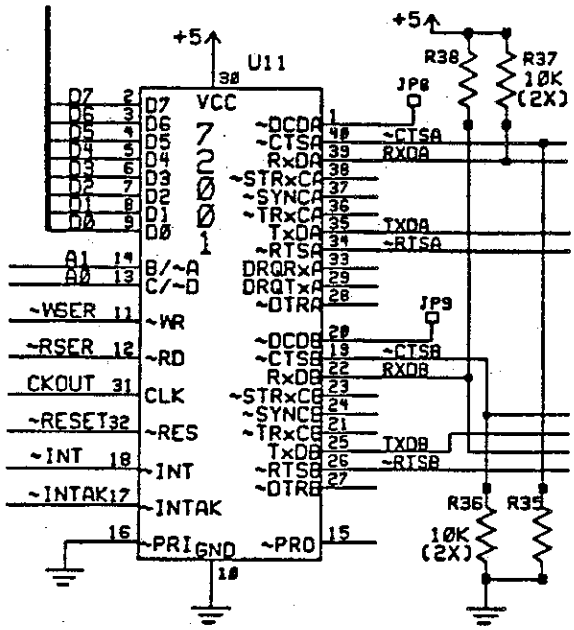


Figure 2-39. Serial I/O Port
(From the Signal Processor Board schematic)

M. Other Inputs

The following additional inputs are provided on port P2:

~ALM_SI	bit 5	Alarm silence
WTRFL	bit 3	Indicates that the reservoir on the water separator is full.
FREQ_MN	bit 2	A square wave signal that tracks the polarity of the AC power line into the RGM and measures the line frequency.

N. Test Points

The table below lists the signal processor's test points and functions:

TP1	P_{AW}	TP11	TVX pulse (buffered)
TP2	A/D ref out	TP12	Digital gnd.
TP3	Flow	TP13	Reset cap.
TP4	Internal O_2	TP14	S/H out
TP5	Pump voltage	TP15	Analog gnd.
TP6	5 MHz	TP16	MINX pleth
TP7	-15V	TP17	CO_2*
TP8	+10V ref.	TP18	N_2O*
TP9	+15V	TP19	Barometer*
TP10	+5V	TP20	Buffered reset

* These voltages appear only with the CX-104 (non-agent) system.

2.8 SpO_2 Oximeter (MINX) Board

Refer to the *Ohmeda MINX Manual*, part number 0380-0900-090.

A. Description

The Ohmeda SpO_2 (MINX) oximeter is a single surface mounted circuit board that provides a method of monitoring noninvasive pulse oximetry. As used in the 5250 RGM, the oximeter board is programmed to use parallel command strings. Data can be output in serial, parallel, or analog formats. Status messages are provided in serial, parallel, or logic level formats. Logic level control inputs configure the board in stand-alone systems.

The SpO_2 oximeter (MINX) board uses the Intel 80C196KA 16-bit microprocessor. This microprocessor has a high level of integration and an internal 10-bit A/D converter. The microprocessor and EPROM are socketed for easy replacement and code enhancement. These components are the only user serviceable parts.

CAUTION: When replacing either the microprocessor or the EPROM on the SpO_2 oximeter (MINX) board, be sure to use a Burndy QILEXT-1 extractor or equivalent to avoid damaging the components.

WARNING: Patient Safety–Use only Ohmeda oximeters and monitors with Ohmeda probes; otherwise, patient injury or equipment damage may result.

B. Power Supply

The oximeter (MINX) receives three separate voltage supplies:

Name	Use	Voltage	Current	Ripple	Pin
+5	Logic	+5V ±5%	30 mA Type 36 mA Max	100 mV	31A, C
+V	Analog	+5V	53 mA Type 64 mA Max	20 mV	29C
-V	Analog	-5V	115 mA Type 138 mA Max	50 mV	30C

The +V and -V analog supplies share a common return path called AGND. The logic return is called DGND. AGND and DGND are tied together at the microprocessor on the module.

Note: The logic supply must be within ± 5% of +5 volts. The + analog must be within + 100 mV of the +5 logic supply. The absolute magnitude of the -V supply must be within ± 5% of +V.

C. Control Inputs

The oximeter (MINX) has 14 control input lines that connect to the 82C55A I/O port lines (configured by software as inputs). If all control inputs are selected low (worst case), an additional 6.5 mA current is required from the +5V power supply.

The MINX system communicates through both the serial and parallel ports. Commands may be sent to configure performance parameters, override defaults, and initiate diagnostic or calibration routines.

2.9 Display Controller Board

A. General Description

The display controller board is a microprocessor based interface for controlling the EL display output, the audible output, and the operator input from the IR touch frame.

There are two audio alarm signal sources, one programmable device for all normal system output (patient warnings and alarms) and a second for total system failure.

B. Processor and Interfacing

Refer to Figure 9-7 in the schematics section.

The processor used in the display controller is the V25 (U5), which is the same as the processor used in the signal processor board. This IC has several built-in functions that minimize the amount of support circuitry needed for the system.

C. System Memory

Refer to Figure 9-11 in the schematics section.

The system RAM (U21) used is a CMOS 32K static part. The ROM is on a plug-in ROM card (J4) with two 64K chips. A 10 MHz oscillator (X1) provides the timebase for all the V25 functions.

D. Communicating to the Signal Processor

Refer to Figure 9-13 in the schematics section.

For communicating to the signal processor board, the Controller uses an RS-422 serial channel. U37 translates between the V25 TTL serial string and the differential RS-422 signals. R36-38 bias and terminate the incoming signal.

E. Watchdog Circuit

Refer to Figure 9-14 in the schematics section.

A MAX691 chip (U27) provides the supervisory functions such as reset and watchdog timer. R7 and R8 allow overriding the watchdog function by permitting U27 pin 11 to be tied to 1.8 volts, while insuring that pin 11 does not float. The processor must change the state of pin 11 at least every 50 mS to prevent the watchdog from being triggered.

If the watchdog is triggered, it will:

- Attempt to restart the processor by pulsing its reset pin
- Enable a system fail audio alarm (generated by U28)
- Operate the yellow alarm LED in the touch frame via Q_2
- Shut down the display matrix

F. Programmable Logic

Refer to Figure 9-10 in the schematics section.

A key part of the circuit is the programmable logic device, U10, which carries out three major functions:

- Performs all the memory decoding for mapping the V25 memory
- Generates all the timing and control signals for the Dynamic VRAM
- Generates various clock frequencies used in the video control circuitry and for the alarm sound IC

U10 has its own 32 MHz oscillator, U15, which provides the clock for the output frequencies and for the state machine, which does the video timing functions.

G. Power Regulation

Refer to Figure 9-8 in the schematics section.

Power is brought onto the board loosely regulated to 6.5 volts and 16 volts, to allow minimum heat generation. The 6.5 is regulated to 5 volts for the logic circuits, and the 16 volts operates the display and the audio power amplifier.

Two low dropout regulators provide the +5-volt supply with minimum power dissipation. One regulator supplies the Yamaha sound IC to isolate it from the digital noise of the rest of the system; the other supplies the rest of the circuits.

H. Audio

A Yamaha single-chip sound synthesizing IC (U32) generates complex audio alarm tones and has software-controllable volume levels. For the system-failure alarm, an additional audio tone circuit operates independently of the V25.

A 4 MHz clock from U10 provides the time base for the internal operations of sound synthesis. A two stage RC low pass filter smooths the switching transients from the synthesizer and mixes the two outputs (one for musical sounds and one for percussion sounds) with the system fail sound generator, U28, R18 and R32 allow volume adjustment to compensate for component variations..

U36 and its related resistors and capacitors drive the speaker that is mounted on the display case.

I. Touch Screen Interface

For user interfacing, the controller board contains a circuit that interprets the inputs from the IR touch frame built into the bezel around the EL display. This circuit uses a 80C32 microprocessor (U16) and associated components to drive LEDs along the bottom and right edge of the touch frame, read analog values from the phototransistors along the top and left edge of the frame, and sense if and where a light beam is broken. The V25 communicates to the 80C32 via TTL level serial interface.

The red and yellow alarm LEDs are also mounted on the touch frame, but are controlled by the V25.

J. Video

Graphic CPU

The 72120 advanced graphic display controller (AGDC), U23, controls the display memory, generates display synchronizing signals, and operates the VRAM's serial output port for loading into external shift registers. It also provides high speed drawing operations for the host CPU (V25) such as line, rectangle, and circle drawing; painting; copying; and rotating.

The V25 accesses the AGDC by two separate chip selects:

- CSIR for accessing the internal registers
- CSDM for accessing the display memory

The V25 can affect the display memory contents in three ways:

- By directly addressing the display memory just as it does RAM or ROM

  In this case, the AGDC acts as an interface between the 8 bit V25 bus and the 16-bit Video memory bus. The hardware interface employs chip select signal CSDM and the handshake signal READY. The AGDC then uses V25 address line A0 to generate either its lower byte enable output (DLBE) or its upper byte enable output (DUBE), depending on whether the address is odd or even.
- Indirectly by using the AGDC to perform high-level functions

  A feature of these functions is that the parameters given to the AGDC can be specified as either actual display memory addresses, or more conveniently, as X,Y co-ordinates relative to a previously set up 0,0 or origin point that is defined as an address and particular bit.
- By using the V25's DMA mode in conjunction with the AGDC's DMA port (one of the internal registers).

  Data can be transferred in either direction between system memory and the display memory using handshaking lines DMARQ from the V25, and DMAAK from the AGDC.

The AGDC requires several support ICs to interface with the V25 and with the video memory. Since the V25 does not multiplex its address and data onto the same lines, U22, U31, and U30 combine the signals for the AGDC, which requires a multiplexed bus. U22 and U31 enable the address bits, and U30 passes the data bits. U1 and U2 multiplex the high and low parts of the address to the video RAMs.

Video Memory and Video Output Circuits

The video memory is made up of four 42264 CMOS Dual Port Video RAM (VRAM) devices (U6-9), organized as 4 bits by 64K. The four devices are used to create the 16-bit wide display memory required by the AGDC.

The dual ports are:

- Data I/O pins for reading/writing
- Serial output port for shifting out data one bit at a time on each of four serial output lines, at a timing determined by an external serial clock (SC) input. Each of the four output shift registers is 256 bits long, and can be parallel loaded from any address in the RAM, in a cycle called Data Transfer. The Data Transfer cycle allows the RAM to be accessed at any address, while simultaneously shifting data out from a different location in the RAM, for sending to the display.

The two ports operate fairly independently, except during the Data Transfer cycle, which only happens every 256 words of display output.

Since the data is shifted out 4 bits in parallel per chip, two 8-bit parallel-in/serial-out shift registers (U13, U14) convert the 16 bits into a single serial output to the EL display.

The pixel clock rate required by the display is 8 MHz. Therefore, the frequency required at the VRAMs' SC inputs for clocking out 16 parallel bits, is 1/16 of that or 0.5 MHz. This is generated by the 74HC161 (U18) connected as a divide-by-16 counter.

This counter uses a preload function for synchronizing the output shifting with the AGDC's horizontal and vertical sync signals. A 74HC74 dual D-Flip Flop (U26) further shapes the timing of the AGDC's horizontal and vertical sync signals into those required by the EL display.

The AGDC uses programmable logic chip (U10) to control the VRAMs and the output shifting through four types of display memory cycles:

- Read cycles — Normally used for manipulating memory data.
- Write cycles — Normally used for manipulating memory data.
- Refresh cycles — Needed for the dynamic VRAMs. Sent only during horizontal blanking, the duration of which can be programmed to provide enough refreshes per screen as required by the RAMs.
- Data transfer cycles — Used specifically for Dual Port VRAMs. A cycle causes a new row of 256 X 4 bits to be loaded into the RAMs' serial output registers.

The AGDC initiates these cycles at the beginning of each screen, and then at regular intervals during the active display time. The AGDC also keeps track of the proper transfer addresses.

K. Test Points

The following lists the display processor test points:

TP1	Revs A through G	Ground
TP2	Revs F and G	Logic level scope-sync for touch panel scan
TP3	Revs F and G	Buffered & inverted analog signal from touch panel
TP4	Revs F and G	15V supply to board
TP5	Revs F and G	6.5V supply to board

2.10 Display Matrix Assembly

The electroluminescent (EL) matrix displays high resolution graphics and text in a self contained enclosure.

The display consists of:

EL-panel — A thin film display mounted with an elastic spacer to an electronic board containing the high voltage circuits required to drive the EL panel. The EL panel has 512 transparent column electrodes crossing 256 row electrodes in an X-Y fashion. Light is emitted when AC voltage is applied at a row-column intersection.

Driver board — Flexible conductors connect the EL-panel to the driver board. A 20-lead cable connects the driver board to a controller board attached to the frame. The controller consists of timing logic, drive voltage waveform generators, and a voltage converter. The voltage converter converts input DC voltages required for the matrix display. The input signal and input power connection for the matrix display are made through a 16-pin flat cable connector on the controller.

Controller — Drive logic signals are processed and drive voltage pulses are generated and controlled on the controller board. The power supply input voltages are +5V and +15 Vdc.

WARNING: The display generates potentially dangerous voltages (high voltage pulses up to 195 Vac). Do not touch the driver controller circuit board during operation.

A. Input Signal Descriptions

The four input signals required for the display are at 5V TTL logic levels:

Signal	Symbol	Description
Video data	VID	Signal that supplies the pixel information to the system. A logic 1 at the VID input corresponds to a lit pixel on the display.
Video clock	VCLK	The VCLK signal shifts data present on the VID line into the display system. VCLK is active on the rising edge.
Horizontal sync	HS	The horizontal sync signal HS selects the 512 bits of data from the VID lines.
Vertical sync	VS	Data of the first 256 lines after VS rising edge will be shown on the display.
Logic supply voltage	Vcc1	Supply voltage for interface logic.
Display supply voltage	Vcc2	Supply voltage converted to required internal supply voltages.

VID data loaded during the last 512 VCLK pulses preceding the falling edge of the HS signal will be displayed on the selected line. The lines to be displayed are selected sequentially by the first 256 HS pulses following the rising edge on the VS pulse.

B. Input Connector Configuration (J1)

Pin	Signal	Pin	Signal
1	Vcc2	9	VS
2	Vcc2	10	GND
3	Vcc1	11	HS
4	Vcc1	12	GND
5	GND	13	VCLK
6	GND	14	GND
7	GND	15	VID
8	GND	16	GND

C. Optical Characteristics

Display area (H x W)	97.7 x 195.2 mm (3.85 x 7.69 in)
Matrix configuration	512 x 256 pixels
Pixel pitch	0.38 mm (15 mil)
Pixel size	0.28 mm (11 mil) square
Pixel luminance	125 cd/m2 (37 fL) typical 80 cd/m2 (23 fL) min
Luminance variation (within the display)	<35%
Color	broadband yellow, peak at 580 nm
Viewing angle	>140°

Notes

3.0 General

WARNING: Perform the checkout procedure before placing the RGM in use. If the RGM fails any test, it must not be placed in use until it has been repaired and checked for correct operation.

This chapter provides checkout procedures to determine whether the RGM is functioning properly. If the RGM fails to meet any of the checks, refer to Chapter 4, "Calibration and Adjustments" or refer to Chapter 6, "Troubleshooting."

Some checkout procedures require you to partially disassemble the machine. Refer to Chapter 7 for disassembly instructions.

Before returning the RGM to clinical use, perform the leakage current and ground resistance tests.

Note: If the RGM fails to perform the zero or span adjustment, the problem may be due to a contaminated measuring chamber or to some other failure in the RGM. Refer to the *5250 Operation and Maintenance Manual* instructions for cleaning the measuring chamber of non-agent versions. For other calibration problems, see the troubleshooting section.

A. Special Tools Required for Checkout Procedure

WARNING: Use of the wrong calibration gas kit will result in improper calibration and the RGM will display incorrect gas concentrations.

The following tools are needed to perform checkout procedures:

- Calibration Gas Kit for standard **non-agent** RGM 6% CO_2, 44% N_2O, 50% O_2 (6050-0001-386) gravimetric standard ±0.05% .
  or
  Calibration Gas Kit for **agent** RGM 6% CO_2, 4% Halocarbon-22, 40% N_2O, 50% O_2 (6050-0001-380).
- Calibrated air flowmeter, 0-600 cc/min (6024-0000-006)
  Accuracy is ±2.0% of the reading or ±division, whichever is greater.
- Pressure gauge 0 to 150 cm H_2O (0-100 mmHg)
- DB9 male connector (pins 2 and 3 shorted) (6050-0001-709)
- Leakage current tester
- Needle-nose pliers or hemostats
- DVM
- Source of dry clinical oxygen at 100% concentration
- DIN Connector, 8-pin (6006-0000-184)
- Oscilloscope or chart recorder (optional)

B. Cleaning the RGM

WARNING: Use caution when handling tubing and other components of the patient circuit. Wear gloves, mask, and gown while handling components that come in contact with the patient's exhalant gas or fluids.

WARNING: In the presence of alcohols, ketones, or other organic hydrocarbon vapors, the 5250 RGM will not indicate accurate readings of anesthetic agent. This includes their presence not only in the sample line or patient circuit, but also alcohol present in a patient's bloodstream.

Unplug the RGM before cleaning. The outside of the RGM can be cleaned with a soft cloth dampened in a mild soap and water solution or 70% isopropyl alcohol.

Do not touch or rub the display panel with abrasive cleaning compounds, instruments, brushes, rough surface materials or anything that can scratch the panel. Do not use organic solvents to clean the display panel. Use a cotton swab saturated with 70% isopropyl alcohol and gently wipe the panel. The unit must be completely dry before use.

3.1 Functional Checkout Procedure

Tools Required for Installation Checkout Procedure

WARNING: Use of the wrong calibration gas kit will result in improper calibration and the RGM will display incorrect gas concentrations.

The following tools are needed to perform the functional checkout procedures:

- Calibration Gas Kit 6% CO_2, 44% N_2O, 50% O_2 (6050-0001-386) gravimetric standard ±0.05% for standard **non-agent** RGM.
  or
  Calibration Gas Kit 6% CO_2, 4% Halocarbon-22, 40% N_2O, 50% O_2 (6050-0001-380) for **agent** RGM.
- Leakage current tester
- Source of dry clinical oxygen at 100% concentration

WARNING: Perform the checkout procedures before using a monitor with a patient. If the monitor fails any test, it must be removed from use until it has been repaired and checked for correct operation.

This procedure provides an initial checkout procedure for monitors after they are unpacked and before first use.

1. Inspect all of the accessories of the 5250 RGM for damage. Replace any broken or damaged accessories. Ohmeda recommends that only genuine replacement parts manufactured or sold by Ohmeda be used for all repairs.
2. Inspect the exterior of the 5250 RGM for damage. Check all the connectors and controls and replace any broken or damaged parts.
3. Switch on the monitor and allow it to warm up for five minutes.
4. During powerup the monitor performs several internal checks. The alarm tone should sound and the red and yellow LEDs will flash. If a problem exists, an alarm message appears. Refer to Section 6.2 "Troubleshooting" for a description of the alarm messages.

A. Barometric Pressure Check

Note: Be sure that the true local barometric pressure used for comparison is **not** corrected to sea level. Absolute barometric pressure is **strongly** affected by altitude. A typical absolute barometric pressure at sea level is 760 mmHg, but at 5000 feet (1600 meters) a typical absolute barometric pressure is 615 mmHg.

1. Select MENU from the Display Screen
2. Select SETUP from the menu.
3. Select Service mode from the Setup Screen.
4. Select PNEUMA from the Service Screen. The Pneumatics Service Screen appears.
5. Select OFF from the Pneumatics Screen. This will turn off the vacuum pump.
6. Obtain and record the **local** barometric pressure (**not corrected to sea level**).
7. If the displayed barometric pressure is more than ± 5 mmHg from the true local barometric pressure, refer to Section 4, "Barometric Pressure Calibration."

B. Zero and Span Calibration Procedure

1. Connect a sample tube to the sample inlet. Check that all connections are properly made and secure.
2. Switch on the monitor and allow it to warm up for five minutes.
3. Perform the system leakage test in Section 3.5C of this chapter.
4. Select MENU from the display screen.
5. Select CALIBRATE INTERNALS from the menu.
6. Select ZERO from the Calibrate Screen. The word ZEROING appears on the screen. After approximately 25 seconds, the message ZERO COMPLETE appears. If error messages appear on the screen, refer to Section 6.7 "Troubleshooting" in this manual.
7. Connect the required Ohmeda calibration gas (as indicated on the screen) to the sample inlet as shown in Figure 3-9.

   WARNING: For the 5250 RGM without Agent, use only Ohmeda calibration gas or calibration gas of 6% CO2, 50% O2, and 44% N2O (±0.05 volume % gravimetric standard). For the 5250 RGM with Agent, use only Ohmeda calibration gas of 4% Halocarbon-22, 6% CO2, 40% N2O, and 50% O2. Refer to Appendix A to order calibration gas.

   Connect the free end of the sample tube to the female luer connector of the calibration reservoir bag. Connect the tubing from the other end of the reservoir to the can of calibration gas.
8. Once the pumping action of the monitor has automatically evacuated the reservoir bag, the RGM automatically generates a one-high-tone and one-low-tone alarm, and the message BEGIN SPAN CALIBRATION appears.
9. Press down on the valve stem of the cal gas canister until the reservoir bag fills but is not pressurized, then touch SPAN on the Calibrate Screen.

   Note: Do not overinflate the reservoir bag, and do not attempt the calibration process if there are any leaks in the bag or tubing. Before the bag empties during a span calibration, add more gas to the bag.
10. After about 20 seconds, when the message SPAN COMPLETE appears, the process is complete. Verify that the values on the screen are the same as those on the calibration gas canister, within the following tolerances: CO_2 ±0.1%, N_2O ±1%, O_2 ±1%, and Halocarbon-22 ±0.1%.

    If the Span calibration is unsuccessful, the message INVALID SPAN appears on the screen, and you should repeat the span calibration. If necessary, refer to Section 6.7 "Troubleshooting".

11. Disconnect the calibration gas from the sample inlet.
12. Select EXIT from the Calibrate Screen to return to the display screen.
13. Store the gas reservoir bag in a location where it will be safe from puncture.

    Note: If the reservoir bag does not fill up, either the canister is empty or the brass restrictor is blocked.

C. SpO_2 Module Checks (if installed)

1. Check the probes for foreign materials such as tape or cotton. Remove any substances that may interfere with the transmission of light between the emitter and detector.
2. Verify that the probes open and close smoothly.
3. Check that the probe is the correct model (see the Ohmeda *Probes Manual*) before connecting it to the RGM. (The model identification tag location is located near the connector on the cable.)

   WARNING: Patient Safety–Use only Ohmeda probes with the RGM; otherwise, patient injury or equipment damage may result.

4. Connect a probe to the SpO_2 probe connector. Check that the probe's plug makes a firm connection.
5. Switch the RGM on. Check that the probe's red emitter LED is on.
6. Attach the probe to either a finger or an ear. Check that the probe cable is not twisted. Verify the following:
   a. A saturation value (SpO_2) of greater than 90% is displayed.
   b. A clean plethysmogram waveform depicting a pulse is displayed
   c. A digital pulse rate (PR) is displayed.
   d. A beep occurs with every pulse. The tone frequency depends on the saturation value. High frequencies indicate high saturation values.

   Note: This beep tone can be disabled from the Setup Screen.

   WARNING: Patient Safety–Prolonged monitoring or patient condition may require changing the probe site periodically. Change the probe site at least every four hours to reduce the risk of blistering, skin erosion, or ischemic skin necrosis (especially if the site is poorly perfused).

7. Verify that the high and low alarm limits for SpO_2 and the Pulse Rate work (if enabled) by setting the high and low alarm limits beyond the indicated readings. Ensure that:
   a. The alarm tone sounds
   b. The alarm light flashes
8. Verify that the probe alarms are functional:
   a. Remove the probe from the finger or the ear and verify that:
      - The alarm message PROBE OFF PATIENT is displayed and the waveform and digital values are not displayed.
      - Three high alarm tones occur when the probe is removed. Pressing alarm silence stops the audio.
   b. Unplug the probe from the RGM and verify that the alarm message NO SPO2 PROBE appears on the screen.